TM 5-661

WAR DEPARTMENT TECHNICAL MANUAL

U.S. Dept. of Army

INSPECTION and PREVENTIVE MAINTENANCE SERVICES FOR

WATER SUPPLY SYSTEMS at FIXED INSTALLATIONS

WAR DEPARTMENT • SEPTEMBER 1945

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TM 5–661, Inspection and Preventive Maintenance Services for Water Supply Systems at Fixed Installations, is published for the information and guidance of all concerned.

[AG 300.7 (28 Jun 45)]

BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL
Chief of Staff

OFFICIAL:
EDWARD F. WITSELL
Major General
Acting The Adjutant General

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Refer to FM 21–6 for explanation of distribution formula.

★★ TECHNICAL MANUAL

INSPECTION AND PREVENTIVE MAINTENANCE SERVICES FOR WATER SUPPLY SYSTEMS AT FIXED INSTALLATIONS

CHANGES }
NO. 1 }

US WAR DEPARTMENT,
WASHINGTON 25, D. C., 28 June 1947

TM 5-661, 21 September 1945, is changed as follows:

89. Hydrants and Mains

* * * * * * *

c. CHECK IN FREEZING WEATHER. In subzero weather * * * on such inspections.

* * * * * * *

(3) After ice is * * * ice is melted.

d. HYDRANT DRAINAGE. (Added) Check each hydrant for barrel drainage prior to onset of freezing weather.

(1) If after closing valve hydrant barrel is slow in draining, a pocket of gravel or crushed rock of adequate size should be installed underneath the drain valve outlet to effect rapid and complete drainage of the barrel.

(2) Where soil conditions or high ground water level prevent complete drainage of the barrel, the drain outlet should be completely closed and the barrel pumped out after each usage.

(3) When nondrainability is discovered during the freezing season, salt may be used to lower the freezing temperature, as an emergency measure, until a gravel pocket or plugs can be installed. In this event, the hydrant should be flushed as soon as possible at the end of the freezing season.

[AG 300.7 (18 Apr 47)]

BY ORDER OF THE SECRETARY OF WAR:

DWIGHT D. EISENHOWER
Chief of Staff

OFFICIAL:
EDWARD F. WITSELL
Major General
The Adjutant General

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For exaplanation of distribution formula, see TM 38-405.

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CONTENTS

SECTION I
GENERAL

1. Purpose and Scope

This Technical Manual covers preventive maintenance services to be performed at all Army water treatment plants, pumping stations, and distribution systems at fixed installations. It is written as part of the Army's preventive maintenance program to help operating personnel keep equipment in satisfactory operating condition and to guide them in systematically detecting and correcting incipient failures before they occur or develop into major defects.

The manual includes instructions on inspecting, cleaning, servicing, lubricating, and adjusting equipment, and a full explanation of how to keep proper preventive maintenance records. Instructions are based on recommendations of experienced engineers and operators and on advice from equipment manufacturers.

Since much of the equipment in a post water plant is practically tailor-made to fit conditions at the post, preventive maintenance operations discussed in this text may occasionally require modification or revision. Even on mass production equipment, differences in installation and service conditions at different posts may make modifications in the preventive maintenance program necessary. Therefore, a survey of plant property, operators' experiences, and manufacturer's instructions must be made at each post to prepare necessary changes to the suggested schedule of preventive maintenance operations.

For maintenance of equipment not specifically mentioned or not fully discussed, consult the post engineer and manufacturers' instructions on maintaining similar equipment.

2. Organization of Manual

To make it easier for maintenance personnel to use this manual, it is divided into sections, each covering maintenance of a particular type of equipment. In addition the following reference guides are used:

a. Item Numbers. (1) An item number (see numbers in time columns of par. 16) is assigned each operation in the inspection and service procedure for a unit. This simplifies preparation of work schedules and maintenance forms (see par. 4), since required maintenance can be shown by listing appropriate item numbers on the work schedule and service record. Maintenance personnel can then determine their specific duties by referring to the schedule for item numbers and to the manual for the discussion under those item numbers.

(2) When the maintenance procedure for a unit includes a reference to another part of the manual, the cross-referenced operation is identified by a dagger (†) instead of an item number. This symbol is not to be used on maintenance records; the appropriate item numbers are to be taken from the paragraph or section given as the cross-reference.

(3) Since it was not feasible to use a consecutive numbering system throughout the manual in assigning item numbers, the same series of item numbers is used occasionally to identify maintenance procedures for different units. In those cases, the type equipment involved will indicate the proper reference and prevent misunderstanding.

b. Time-schedule Columns. Time-schedule columns printed in the left-hand margins (see par. 16) help in scheduling maintenance operations.

(1) Location of an item number in one of the columns shows the minimum frequency with which that operation must be performed.

(2) An asterisk (*) in the annual *column* indicates varying maintenance frequency, depending on nature of the installation and conditions of use. In such instances, each post determines suitable frequencies on the basis of manufacturer's recommendations and its own experience with the equipment.

(3) Total maintenance required on a unit during a particular period can be determined quickly by checking the appropriate time-schedule column and noting the total of item numbers listed.

3. Equipment Classification

a. Classification Code. Setting up an equipment classification code helps identify equipment in the system and simplifies record keeping. The decimal coding method is suggested. In this method, *W* represents water equipment, the *digit* stands for class of equipment, and the *decimal* differentiates between types of equipment in each class. The following is a typical classification code:

W1.0 Prime movers.
  W1.1 Electric motors.
  W1.2 Gasoline engines.
W2.0 Wells or water supply.
  W2.1 Straight-bored.
  W2.2 Large gravel-wall.
  W2.3 Large dug.
W3.0 Dams or impounding reservoirs.
W4.0 Well pumps.
  W4.1 Tribune.
W5.0 Centrifugal pumps.
  W5.1 Mixed-flow.
  W5.2 Axial-flow.
W6.0 Rotary pumps.
W7.0 Reciprocating.
W8.0 Pump auxiliaries.
W9.0 Basins.
  W9.1 Revolving type concentrators.
W10.0 Chemical feeders.
W11.0 Filters.
  W11.1 Pressure filters.
  W11.2 Gravity sand.
W12.0 Zeolite softeners.
W13.0 Recarbonation equipment.
W14.0 Aeration equipment.
W15.0 Meters.
W16.0 Hydrants.
W17.0 Tanks.
W18.0 Air-relief valves.
W19.0 Altitude valves.
W20.0 Hydraulic-cylinder valves.
W21.0 Gate valves (buried).
W22.0 Gate valves (not buried).
W23.0 Globe valves.

b. Equipment Numbering. To insure proper identification and correct records, each post engineer must assign an identification number to each major piece of equipment or accessory in the distribution system, water pumping stations, and water treatment plant. There is no set numbering method. A hyphenated system is recommended: the first part would show building or functional structure number, taken from the real property card; next would be the equipment classification code; the last figure in the series would distinguish between a number of identical units located in the same building, and is necessary only when a building contains more than one unit of a particular type. In this method, identifying number T431–W11.2–5 would represent gravity sand filter No. 5 in building T431.

SECTION II

RECORD KEEPING

4. Utilities Inspection and Service Record

Preventive maintenance programs are effective only if careful, accurate, and complete records are kept of all work done. In no other way can the post engineer insure that all personnel are carrying out their individual responsibilities and that all equipment is being properly maintained. In post water plants, WD AGO Form 5–34 (Utilities Inspection and Service Record) (fig. 1), is used as the work sheet and record card of inspections and services performed.

a. When Used. Forms are prepared by the sanitary engineer or works supervisor after a study of the maintenance needed for each piece of equipment; assistance of the plant foreman and operators may be enlisted.

(1) Separate forms are made out for each major separate piece of equipment, including accessories needed to operate it. Thus, the card for a water pump includes pump, motor, float or pressure control, and valves. A gasoline-engine primary or stand-by drive or a control is carried on separate cards. (See also par. 17*g*.)

(2) If inspection and service operations on a unit include more than 20 steps (*b*(4) below), a separate card is prepared for one or more components of the unit.

b. Filling in Form. Procedure for making out a record card is discussed below. For an example of a completed card, see figure 2.

(1) *Equipment number*. Insert identification number (par. 3*b*).

(2) *Description*. Describe equipment briefly but in enough detail so it can be identified readily.

(3) *Preventive maintenance to be done by*. Show job title and name of person responsible for maintenance; this should be the person who actually operates the equipment. He is also responsible for reminding the chief operator, superintendent, or other supervisor of any special semiannual or annual inspections they are to make, and for insuring that the supervisor makes an appropriate entry on the record card after inspection is completed.

(4) *Work to be done*. Study manual and note all inspection and service required. Enter in this space the paragraph or subparagraph heading describing the operation. Add any operations not covered in manual but needed to maintain a particular unit. *Make sure all necessary inspections and services are shown on record card.* List operations in order of frequency of performance, with daily service first.

(5) *Item number*. Identify each operation with proper item number. Where the same item number is used to identify different operations, differentiate between them by adding a letter to one of the numbers; thus, if *1* is used twice, write one of them as *1a*.

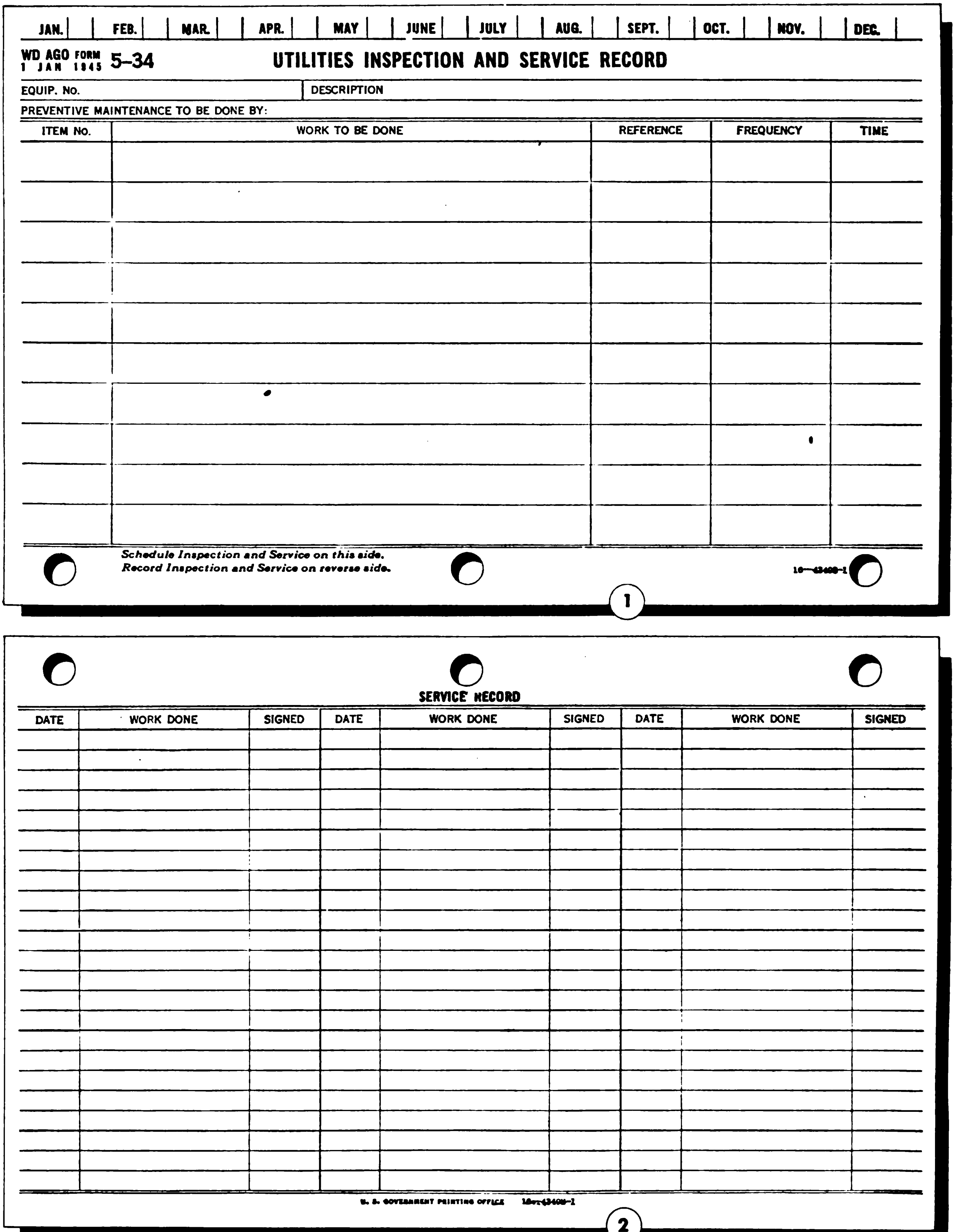
(6) *Reference*. Insert paragraph numbers to facilitate reference to manual.

(7) *Frequency*. Record frequency of operations, as shown in time-schedule columns. Modify suggested frequencies to fit local conditions.

(8) *Time*. Show specific day or month service is due (see fig. 2①). Stagger quarterly, semiannual, and annual inspections to prevent rush periods and conflicts in schedule. Choose season when work can be done best.

(9) *Tab index*. Mark an X at top of form alongside each month during which work is to be done or report submitted. This helps schedule operations, since over-all work in the plant in a given month can be quickly determined by reference to the tab index.

(10) *Service record* (fig. 2②). On back of card, record date and item number whenever maintenance is performed, and initial. If service needed is beyond the ability or authority of the inspector, he requests skilled help and enters the request in the *work done* column. For example, if inspection of a motor reveals a grooved commutator, the entry would read "Electrician needed to complete item 51—commutator grooved."



JAN. | FEB. | MAR. | APR. | MAY | JUNE | JULY | AUG. | SEPT. | OCT. | NOV. | DEC.

WD AGO FORM 5-34
1 JAN 1945

UTILITIES INSPECTION AND SERVICE RECORD

EQUIP. No. | DESCRIPTION

PREVENTIVE MAINTENANCE TO BE DONE BY:

ITEM No.	WORK TO BE DONE	REFERENCE	FREQUENCY	TIME

Schedule Inspection and Service on this side.
Record Inspection and Service on reverse side.

[illegible]

1

SERVICE RECORD

DATE	WORK DONE	SIGNED	DATE	WORK DONE	SIGNED	DATE	WORK DONE	SIGNED

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2

Figure 1. Post water plant utilities inspection and service record card.

JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
X	X	X	X	X	X	X	X	X	X	X	X

WD AGO FORM 5–34
1 JAN 1945

UTILITIES INSPECTION AND SERVICE RECORD

EQUIP. No. T671-W11.2-1 DESCRIPTION GRAVITY SAND FILTER NO 1

PREVENTIVE MAINTENANCE TO BE DONE BY: FILTER PLANT OPERATOR, FIRST SHIFT, JOHN DOE

ITEM No.	WORK TO BE DONE	REFERENCE	FREQUENCY	TIME
3	INSPECT SAND OR ANTHRAFILT SURFACE	71b	MONTHLY	JAN 8
4	INSPECT GRAVEL-BED LEVEL	71g	"	"
10	INSPECT LEVEL AND ELEVATION (WASH-WATER TROUGH)	72a	"	"
5.	PROBE FILTERS	71c	SEMIANNUALLY	MAR DEC
6	INSPECT SAND BELOW SURFACE	71d	"	JUNE DEC
7	SCRUB SAND	71e	"	" "
8	ANALYZE SAND	71f	"	" "
9	CHECK GRAVEL BED	71h	"	" "
14	INSPECT FOR CORROSION (WASH-WATER TROUGH)	72b	ANNUALLY	DEC
13	INSPECT FILTER BOTTOM	71i	"	"

Schedule Inspection and Service on this side.
Record Inspection and Service on reverse side.

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1

SERVICE RECORD

DATE	WORK DONE	SIGNED	DATE	WORK DONE	SIGNED	DATE	WORK DONE	SIGNED
1/7/47	3, 4, 10 OK	J.D.						
2/8	3, 4, 10 OK	J.D.						
3/6	3, 4, 10, 5, OK	J.D.						
4/7	3, 4, 10 OK	J.D.						
5/3	3. 4, 10 OK	J.D.						
6/9	3, 4, 10, 5, 6 OK	J.D.						
"	7- JETTED	J.D.						
6/10	8- 1% LOSS	J.D.						
"	9 OK	J.D.						
7/5	3, 4, 10 OK	J.D.						
8/6	3, 4, 10 OK	J.D.						
9/8	3, 4, 10 OK	J.D.						
10/2	3, 4, 10 OK	J.D.						
11/4	3, 4, 10 OK	J.D.						
12/7	3, 4, 10, 5, 6, 7 OK	J.D.						
12/9	8- 1% OK	J.D.						
"	9 OK	J.D.						
"	FILTER NOT TORN DOWN	J.D.						
12/9	14 PAINTED	J.D.						

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2

Figure 2. Typical filled-in utilities inspection and service record.

The work order number is entered alongside under column headed *signed*, and is initialed.

When all spaces on the service record are filled in, staple a blank card to the original.

5. Record-card System

The record-card system consists of duplicate sets of WD AGO Form 5–34, one set making up a *field file* and the other a *master file*.

a. Field File. The field file is made up of the forms forwarded to inspectors who maintain the equipment. The inspector is also given a manual so he can study it and become familiar with his specific duties. Inspectors make all service entries and keep their copies of the forms up to date. Forms are in the inspectors' possession except at the beginning of the month, when they are sent to the supervisor for transfer of consolidated data to the master file.

b. Master File. Record cards in the master file are arranged by equipment number and kept in the work supervisor's office. A movable tab is placed on the tab index of each card, above the month during which maintenance for the unit is next scheduled. When inspectors turn in the field file at the beginning of the month, entries are checked to insure that all work was done and a *summary of the entries* is transferred to the master file. The summary includes any special difficulties encountered by the inspector, work orders required for maintenance, and the consolidated entry of items checked. After all entries are made, movable tabs are then shifted to the next month when maintenance is scheduled and field-file cards are returned to inspectors. Any tabs in the master file that are not moved are readily apparent. Since they indicate that a field-file card was not turned in or that work was not completed, immediate follow-up is essential.

SECTION III
GENERAL PREVENTIVE MAINTENANCE SERVICES

6. Tools and Maintenance Supplies

An adequate supply of the tools and maintenance supplies needed to service the specialized equipment in post water plants is essential to efficient conduct of the preventive maintenance program.

a. Tools Needed. The number and type of tools needed varies, depending on the degree of mechanization of the plant.

(1) To determine the kind and number of tools required, review all record cards and note the tools needed for the operations listed. Examine all equipment for bolt, nut, and pipe-wrench sizes; note whether offset screw drivers, setscrew wrenches, punches, and chisels are needed.

(2) Provide operators with a work bench and vise.

(3) Before requisitioning tools that would be used only rarely, determine whether they can be borrowed as needed from other shops on the post. If they can be borrowed, enter the source on the front of the record card, under the step for which they are needed.

b. Tool Boards. To keep tools instantly available and to insure against loss, install them on wood or metal tool boards (fig. 3).

(1) Plan tool boards so they can hold all tools, including odd-shaped or odd-sized tools such as extension cords, oilcans, grease guns, gaskets,

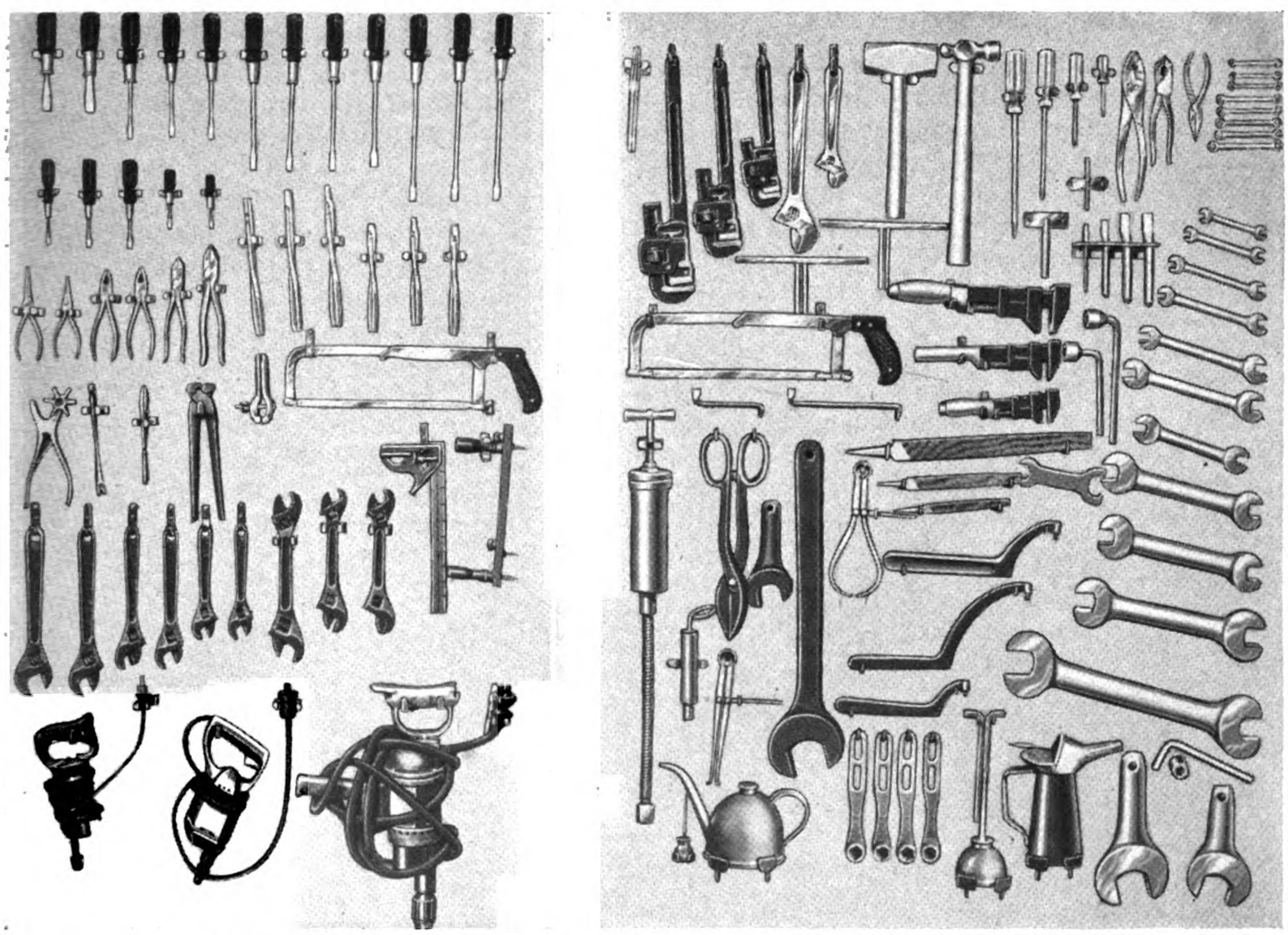

Figure 3. Tool boards. (Note use of brackets for mounting three-dimensional tools.)

electric drills, folding rules, etc. *Never* store tools in bins, benches, or drawers.

(2) When building tool boards, leave space for adding tools.

(3) Paint tool boards a solid color; in contrasting color, paint the outline of each tool in the proper place on the board. This shows clearly which tools are in use, and simplifies returning them to the board when they are no longer needed.

c. Care of Tools. Tools must be kept in good condition and must be properly used. Never use screw drivers for levers or chisels, pliers for wrenches, Stillson wrenches on hard rubber pipe or on bolts and nuts, or a wrench for a hammer. If the proper tool for an operation is not available, arrange for its procurement immediately.

(1) Inspect tool board daily and check for missing tools. All tools not on the board must be accounted for as being in use. Keep tools and tool board clean. Check condition of paint annually, and repaint if necessary.

(2) Inspect all tools monthly, and replace damaged or badly worn tools. Sharpen screw drivers, chisels, and grind mushroom heads on chisels, punches, cold cuts, etc. Clean all tools thoroughly. Lubricate tools as needed.

d. Tool Lists. Table I is a check list to help in setting up tool supplies. This table is *not* an inventory; the final determining factor is actual plant needs.

e. Safety Equipment. Appropriate safety equipment should be obtained and should be available at all times. Such equipment includes safety harnesses, ropes, ladders, gas masks, protective clothing, safety lamps, toxic-gas and oxygen-deficiency indicators, and explosimeters. Safety equipment must be used for any hazardous maintenance operation. Presence and extent of toxic gases and degree of oxygen deficiency must be determined before personnel are allowed to enter inclosed tanks and chambers.

f. Spare Parts. Proper performance of preventive maintenance schedules requires an adequate stock of spare parts on hand. The kind and number of spare parts which should be stored depends on service conditions of parts, importance of the equipment to utility service, and the ease with which they might be repaired.

Examine each piece of equipment in the plant and compile a spare-parts inventory. In making this inventory, pay particular attention to small details such as shear pins, nuts, bolts, diaphragms, fractional-horsepower motors, gear reducers, solenoids, contacts, brushes, etc. Check the spare-parts inventory semiannually.

g. Preventive Maintenance Supplies. Each year, water plants prepare a supply list of materials that might be needed for preventive maintenance operations. To prevent operating delays and forced shut-downs, the list must be complete, with the kind and amount of supplies depending on the particular plant and the scheduled preventive maintenance. The following is a partial check list of supplies generally required: fuses; gaskets and washers for chemical pumps; chlorinators; hoses; pipe fittings; pipe-jointing materials; pipe-repair bell clamps and sleeves; packing; lubricants; touch-up paints; solvents (carbon tetrachloride, kerosene); detergents (trisodium phosphate and the like); concreting materials; mercury; manometer fluids; lumber; nails; bolts; nuts; screws; valve disks (for renewable seat valves); and hose clamps and couplings.

Table I. Tool check lists

Mechanics' tools	Pipefitters' and pipe-laying tools	Portable power tools (electric or air)	Rigging equipment	Carpenters' tools	Miscellaneous
Bearing-scrapping tools. Clamps. Drifts. Drills, taps, and dies (US Standard and SAE). Feeler gauges. Files. Grease guns and special lubrication devices. Hacksaw. Hammers. Offset screw drivers. Packing tools. Pliers (long-nosed, wire-cutting, etc.). Punches. Reamers. Screw drivers. Screw extractors (easy-outs). Shears and tin snips. Soldering equipment. Taper gauge. Wheel and gear pullers. Wrenches: Box. End. Setscrew. Socket.	Blow torches. Calking tools. Chain tongs. Copper-pipe bending and flaring tools (set). Diamond points. Melting pots. Paving breaker (including portable air compressor). Pipe: Cutters. Derrick (tripod type). Dies and taps. Reamers. Vise (portable). Plumbers' furnaces. Pouring bands and funnels. Pouring ladles. Sledge hammers. Tapping machine (for installing service connections). Wedges. Wrenches: Strap. Stillson. Yarning irons.	Drills. Hammers: Calking. Chipping. Grinders. Paving breakers. Sanders. Saws. Vacuum cleaners and blowers.	Block and tackle. Chain. Chain blocks. Dollies. Jacks. Rollers. Rope. Slings. Trucks. Wood blocking (adequate and readily available supply). Wrecking and prying bars.	Axes. Brace and bits. Chisels. Circular power saw (bench size). Clamps. Crowbars. Hammers. Hatchets. Levels. Mallets. Miter box. Planes. Saws. Screw drivers. Sledges. Squares and markers.	Air compression (portable). Concrete mixer. Ditch-digging tools (shovels picks, etc.). Extension cords. Fire-hydrant wrenches (special for separate makes of hydrants). Gas masks. Goggles. Ladders and scaffolding. Light plants (portable). Paint brushes and containers. Paint sprayers. Pumps (portable). Respirators. Stop watches. Tachometers and speed indicators. Tarpaulins. Thawing and heating torches. Thermometers. Pyrometers. Valve keys. Wheelbarrows.

7. Lubrication

The variety of types of equipment and conditions under which they operate make proper lubrication practices extremely important. Improper lubrication causes damage to wearing surfaces, increased maintenance costs and power consumption, and outages.

a. USE. War Department Lubrication Orders and Lubrication Charts prescribe the lubricating oils, greases, preservatives, and corrosion preventives used to lubricate and preserve all water treatment plant equipment. These products are listed in tables II through VI to help the post engineer in procurement. The post engineer and his staff must familiarize themselves with these tables to insure proper use of lubricants and preservatives and compliance with lubrication instructions given in other sections of this manual. Questions on use of products listed or on substitutes for them must be referred to the Office, Chief of Engineers. When a War Department Lubrication Order is published on any piece of equipment, lubrication prescriptions in it are mandatory and supersede any conflicting instructions given in this manual.

b. SUBSTITUTING LUBRICANTS. Lubrication instructions given in this manual include recommended types and intervals. However, these are only guides and may require modification depending on the use of equipment and severity of operating conditions.

c. PRECAUTIONS. (1) Never overlubricate. Too much lubricant causes antifriction bearings to heat up and may damage grease seals. In motors, overlubrication may damage windings. Ninety percent of Army plant motor failures are caused by overlubrication.

(2) Do not lubricate incompletely inclosed or inadequately guarded machinery while it is in motion.

(3) Guard against dust, grit, and abrasives getting into containers used for storing lubricants. Store oils and greases in a dust-free location and keep containers covered at all times. Wipe spouts and lips clean before using container; clean grease guns and fittings before applying grease.

Table II. Lubricating oils

Standard product nomenclature	Product symbol	Grade or type	Temperature for use	Stock No.	Issuing service
Oil, engine	OE 10	SAE 10		14-0-2150	QMC
Navy symbol	NS 3050 [1]	SAE 20	Above 0° F	14-0-2662	QMC
Oil, engine	OE 30	SAE 30		14-0-2154	QMC
Navy symbol	NS 3080	SAE 40	Above −15° F	14-0-2670	QMC
Oil, engine	OE 50	SAE 50		14-0-2156	QMC
Navy symbol	NS 2075	2075	Above −10° F	14-0-2586	QMC
Navy symbol	NS 2110 [1]	2110	Above 0° F	14-0-2595	QMC
Navy symbol	NS 2135	2135	Above 0° F	14-0-2610	QMC
Navy symbol	NS 2190	2190	Above 35° F	14-0-2605	QMC
Navy symbol	2190T [2]	2190T	Above 35° F	14-0-2879	QMC
Navy symbol	NS 2250 [3]	2250	Above 35° F	14-0-2640	QMC
Navy symbol	NS 3065 [3]	3065	Above 5° F	14-0-2663-8	QMC
Navy symbol	NS 3100	3100	Above 25° F	14-0-2685	QMC
Navy symbol	NS 3120	3120	Above 30° F	14-0-2700	QMC
Navy symbol	NS 4065	4065	Above 35° F	14-0-2715	QMC
Navy symbol	NS 5150	5150		14-0-2745	QMC
Navy symbol	NS 5190	5190		14-0-2760	QMC
Navy symbol	NS 6135	6135		14-0-2775	QMC
Navy symbol	NS 8190	8190		14-0-2820	QMC
Lubricant, exposed gears, chains, and wire rope.	CW 2	Grade 2		14-L-165	QMC
Oil, clock and watch	OCW	Allyear	Above 22° F	14-0-680	ORD
Oil, typewriter	TW	One grade		53-0-253	QMC
Lubricant, gear, universal	GO 90	90	Above 32° F	14-L-188-5	QMC

[1] Quenching.
[2] Turbine, noncorrosive, 55-gallon container.
[3] Machine, extra heavy.

Caution: NS 4065, 6135, and 8190 are compounded oils and should never be mixed with steam-turbine oils or engine oils in circulating systems, ring-oiled bearings, or inclosed crankcases employing splash feed, as they will cause the oil to emulsify. Do not use OE 50 in an engine crankcase.

Note. Navy symbol (NS) oils are classified by the first digits as follows:
2—Forced-feed oils, low-viscosity index.
3—Forced-feed oils, medium-viscosity index.
4—Compounded marine-engine oils.
5—Mineral cylinder oils.
6—Compounded steam-cylinder oils (tallow).
8—Compounded air-cylinder oils.

In class 2 oils the second, third, and fourth digits indicate viscosity in Saybolt Universal (SBU) seconds at 130° F. In all other classes, digits indicate SBU seconds viscosity at 210° F.

d. Grease Fittings. Lubrication is simplified, number of grease guns required is reduced, and use of wrong lubricants prevented if all lubrication points requiring the same grease are fitted with the same type grease-gun fitting. Each gun can then be plainly marked with the kind of grease to be used in the gun.

e. Identification Symbols. When all lubricants needed in the plant have been obtained, mark the product symbol on all containers, and on all grease guns and oilers used with a particular grade lubricant. The correct symbol should also be marked near oil cups and lubrication fittings to insure use of the right lubricant.

Table III. *Greases*

Standard product nomenclature	Product symbol	Grade or type	Temperature for use	Stock No.	Issuing service
Grease, general-purpose	CG 0	No. 0	Below 32° F	14-G-1179-5	QMC
Grease, general-purpose	CG 1	No. 1	Above 32° F	14-G-1220-5	QMC
Grease, general-purpose	WB 2	No. 2	All temps	14-G-1230-5	QMC
Grease, water-pump	WP	No. 4		14-G-1384-5	QMC
Grease, No. 0	OG 0	One grade only	Above 32° F	14-G-1435-605	ORD
Lubricant, plug valve	LV	Sticks, ⅜ dia		14-5570-640-024	CE
Grease, graphited, light	GG	One grade only; 1-lb. can.		14-G-938-16	ORD
Compound, antiseize, mica base.	AS	One grade only; 1-lb. can.		52-C-3081	ORD
Grease, ball and roller bearing.[1]	BR	One grade only; 25-lb. pail.	All temps	14-G-984-25	ORD

[1] Gargoyle BRB No. 4, Socony-Vacuum Oil Co. Proprietary brand acceptable. Government specification not yet available.

Table IV. *Preservative lubricating oils*

Standard product nomenclature	Product symbol	Grade or type	Temperature for use	Stock No.	Issuing service
Oil, lubricating preservative, medium.	PM	Medium	Above 32° F	14-O-2833-125	ORD
Oil, engine, preservative	PE 10	Grade 1 (SAE 10)	Above −10° F	14-O-2370-5	ORD

Table V. *Corrosion preventives*

Standard product nomenclature	Product symbol	Grade or type	Temperature for use	Stock No.	Issuing service
Compound, rust-preventive, light.	CL	Light	Up to 120° F	14-C-349-880	ORD
Compound, rust-preventive, thin film.	CT	One grade only		14-C-507-10	ORD

Note.—Rust-preventive compounds may require heating before they can be applied.

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Table VI. Recommended uses for lubricants

Equipment	Oil or grease
Air compressors:	
Vertical- and closed-crankcase type, single-acting, single-stage-crankcase type, supplying splash lubrication to compressor cylinders and bearings:	
For gauge pressure of 100 psi or less.	NS 2110, NS 3050
For gauge pressure over 100 psi.	NS 2135, NS 2190, NS 3050
Horizontal multistage type air cylinders.	NS 2135, NS 2190, NS 3050
External lubrication, sight feed and wick oil cups or hand oiling.	NS 2135, NS 2190, NS 3050
External lubrication, circulating systems or splash type crankcases.	NS 2110, NS 2135, NS 3050
Cylinders:	
Wet conditions	NS 8190
Dry conditions	NS 2190, NS 2250, NS 3065
Bearings:	
Ball; all temperatures	BR
Ball, low-pitch line speed:	
Operating temperature below 32° F.	NS 2075
Operating temperature 32° to 150° F.	NS 2190, NS 2250, NS 3065
Ball, medium-pitch line speed:	
Operating temperature below 32°F.	NS 2075
Operating temperature 32° to 150° F.	NS 2135, NS 3050
Ball, high-pitch line speed:	
Operating temperature below 32° F.	NS 2075
Operating temperature 32° to 150° F.	NS 2110, NS 3050
Ring-oiled, small, miscellaneous	NS 2110
Kingsbury thrust bearing	NS 2190T
Thrust (other than Kingsbury, subject to water).	NS 4065
Thrust (other than Kingsbury, not subject to water).	NS 2135, NS 2190
Bronze guide	WB 2
Countershaft	CG 1
Differential (inclosed)	NS 3150, NS 5190, NS 6135
Eccentric	NS 3065, WB 2
Guide	CG 0, CG 1
Oilite bronze bushings	OE 10, OE 30
Pillow block	WB 2.
Underwater-babbitted	CG 0, CG 1
Universal joint, slip splines	GO 90, BR.
Chain drives:	
Roller	OE 30, NS 3080, CG 0, CG 1
Roller (inclosed)	Winter, NS 2075; summer, NS 3065
Roller (semi-inclosed)	Winter, NS 3080; summer, NS 6135
Slow-speed	CW 2, OE 30
Medium-speed	NS 5190
Couplings	NS 6135
Drive jaw clutch	OE 50
Gear case or gear head	Low temperature, NS 3080; high temperature, NS 5190
Gears:	
Herringbone	Winter, NS 2075; summer NS 3065.
Helical	Winter, NS 2075; summer NS 3065.
Gears—Continued.	
Motor reducers	Winter, NS 3050; summer NS 2135.
Open	NS 5190, WB 2.
Planetary	Winter, NS 2075, NS 2110; summer, NS 2135.
Worm and pump transmission	Winter, NS 3080, NS 3100; summer, NS 6135.
Packing, sludge pumps	OE 30, NS 4065, NS 6135.
Seal packings	WP.
Shafting:	
Large	NS 2190, NS 3065.
Small	NS 2110, NS 2135, NS 3050.
Shear pins	OE 30, WB 2.
Sheaves	CG 1, CG 0.
Solenoid oilers	OE 10, NS 3050.
Valve stems	WB 2.

Note: When in doubt on prope lubricant to use, consult the post engineer.

8. Solvents

a. Types. The only cleaning solvents used in the water plant are kerosene, dry-cleaning solvent, and carbon tetrachloride, the latter is used to clean certain bearings, slanting shafts, and chlorinators. Solvents such as gasoline and naphtha are not safe because of their low flash points. Benzene (or benzol) not only has a low flash point, but is also extremely toxic.

b. Hazards. (1) *Kerosene.* When used for cleaning indoor equipment, the room must be well ventilated. Kerosene must be used cautiously to avoid spilling and exposure to flame.

(2) *Carbon tetrachloride.* Although carbon tetrachloride is noninflammable and is recommended for use in confined places, it is toxic to human beings when exposure is prolonged and concentrations exceed 100 parts per million. Most people coming from fresh air into a room containing that concentration of carbon tetrachloride vapor can detect a barely perceptible odor.

c. Storing. (1) *Kerosene.* Store kerosene in properly marked and capped cans in an unheated room, or preferably, outdoors or in a detached shed.

(2) *Carbon tetrachloride.* Carbon tetrachloride must be stored in clean, dry, airtight containers, away from heat. Carbon tetrachloride which contains even a slight amount of moisture is highly corrosive.

d. Use of Cleaning Solvents. (1) When using cleaning fluids, be sure the solvent is completely evaporated before placing equipment back in service. After cleaning bearings or machined parts, place parts on clean rags or paper, allow to dry quickly, and immediately dip in oil or apply lubricant. Do not leave rust-susceptible parts exposed to air after cleaning.

(2) Before using a solvent to clean electrical equipment, blow off or otherwise remove all loose dirt and dust; then dip a rag in solvent and wipe it on the insulation. Spraying can be used but extra precautions against fire or health hazards are necessary.

(3) Solvents used to clean bearings and machinery other than electrical windings can be reused after insoluble matter is strained out. Filter solvent into a container through waste or cloth placed in a funnel. Label containers plainly with the word *used.*

9. Mercury Cleaning

Mercury used in manometers and other instruments picks up dirt and corrosion products of ferrous and nonferrous metals, moisture, and must be cleaned periodically.

a. Equipment. The only equipment needed is a glass funnel and a glass or porcelain-enamel container. The funnel is prepared by heating the tip and drawing it out to an extremely small opening so the mercury will run through in a fine stream. The container must be large enough to hold all the mercury to be cleaned at any one time, and must have a neck small enough to support the funnel. If possible, the container should have an outlet at or near the bottom to make it easier to remove cleaned mercury from the container.

b. Potassium Hydroxide Treatment. To clean mercury which is contaminated with oil or grease—

(1) Fill container with a 10 percent solution of potassium hydroxide. If container has a bottom outlet, attach a rubber hose to outlet and seal it with a pinch clamp or by elevating end of hose.

(2) Pour mercury through funnel into potassium hydroxide solution. Mercury, being heavier, sinks to bottom of container; potassium hydroxide solution removes oil and grease as mercury passes through.

(3) After all mercury has been passed through the solution, draw mercury off through the hose into a clean glass or porcelain-enamel container. If receptacle used for cleaning the mercury does not have a bottom outlet, remove mercury by first pouring off the potassium hydroxide solution and then pouring mercury into a clean container.

c. Dilute Nitric Acid Treatment. Nitric acid treatment is used to remove solids of corrosion products and water. After mercury has been degreased, or for the first cleaning if degreasing is unnecessary

(1) Fill a clean container with a solution of one part concentrated nitric acid and three parts water.

(2) Pour mercury through funnel into nitric acid solution.

(3) Remove mercury as in *b*(3) above.

d. Washing. After treating mercury with potassium hydroxide and nitric acid, wash it to remove traces of these reagents. Fill a clean container with distilled water, pour mercury through funnel into distilled water, and collect as before. Repeat washing process at least three times, then test mercury with litmus paper to determine acidity or alkalinity. If acid reaction is obtained, continue washing, testing with litmus paper until mercury gives neutral reaction.

e. Drying. As the last step in the cleaning process, remove all water from the surface of the mercury by pouring it on to absorbent blotting paper or cotton. Moisture can also be removed by placing the mercury in a glass or porcelain dish and heating it to slightly above 212° F., the boiling point of water.

Caution: Do not breathe any of the fumes when the mercury is being heated. Be careful not to heat mercury too near its boiling point, 674.5° F. FUMES FROM HOT MERCURY ARE EXTREMELY POISONOUS.

f. Cleaning Containers. Cleaned mercury must not be put back into dirty glassware or into a manometer with dirty tubes. Prepare glassware for use with mercury by washing it with a solution of sulphuric acid and potassium dichromate or sodium dichromate. Prepare the solution by adding dichromate crystals to concentrated sulphuric acid until no more crystals will dissolve. Then add a little extra dichromate so a few crystals remain undissolved in the bottom of the container, insuring that the solution is definitely saturated.

g. Precautions. (1) Handle nitric acid solution and dichromate solutions carefully because they are injurious to one's person and clothes. Wear suitable protective clothing.

(2) Whenever possible handle mercury under water to avoid all possibility of mercury poisoning by absorption through the lungs and to keep cleaned mercury from becoming recontaminated by oxidation.

10. Painting

Periodic painting is necessary to protect metal parts of equipment from corrosive action of water treatment plants. Frequency of painting varies from 1 to 10 years, depending on type of paint used, method of application, and conditions of wear. Always paint metal surfaces before corrosion becomes so severe that equipment is damaged. Surfaces must be prepared before they can be painted; sandblast metal surfaces if practical, or clean them thoroughly with sandpaper and a wire brush. Only specially prepared paints should be used on damp surfaces where drying temperatures are less than 40° F.

Note. Corrosion-preventive compounds (table V) may be used in moist places and in pits where paint would not last.

11. Care of Functional Structures

Functional water-pumping and treatment structures such as wet and dry wells, chambers, settling tanks, filters, and basin walls require periodic inspection, normally annually. Tanks should be emptied for this inspection. Masonry structures should be checked for spalling, porosity cracks, and breaks in expansion-joint seals. Wood structures and appurtenances such as baffles, gates, dividing walls, flumes, and channel covers should be checked for rot, warping, and checking.

a. MASONRY STRUCTURES. (1) *Spalling.* If spalling is allowed to continue, it causes progressively greater damage to the structure. It should be repaired as follows:

(*a*) Repair concrete surfaces with shallow spalling with special cements such as Cameo, Ruggedwear, Stonehard, or similar materials which permit carrying the patch to a feather edge.

(*b*) Patch deeply spalled or porous concrete with ordinary cement, using approximately the same mix as the original concrete. Rich grouts cause shrinking.

(*c*) Keep checked concrete from spalling by sealing the surface with bituminous, asphalt, or synthetic resin base paint suitable for contact with water.

(2) *Cracks.* Cracks also lead to more serious damage, especially to structures exposed to heavy freezing. Therefore, it is important that all cracks be repaired immediately on discovery. Whenever possible repairs should be made from inside the tank. Asphaltic admixtures to grout or asphalt-covered cloth membranes may be required to allow for contraction and expansion. If there is no movement, repair cracks with special cements (see (1) (*a*) above). If water is flowing from the crack, use special quick-setting mortars, insert a drain, or alternately pump sodium silicate and calcium chloride solutions into the crack. (For information on the latter method, write to the Philadelphia Quartz Company, Philadelphia, Pennsylvania.)

b. WOOD STRUCTURES AND APPURTENANCES. Wood does not deteriorate under water, but wood at or above the waterline rots quickly unless it is coated annually or more often with cresote or other preservative. To determine the need for preservative, inspect channel and basin covers and well stairways for soundness and ability to carry loads safely. Check tie rods, bolts, and other supporting steel work for corrosion, and repaint or replace as required. Replace or patch warped boards where necessary, such as in division walls and gates on sludge beds.

c. FROST HEAVING OF TANKS. Drained tanks heave in cold weather if ground-water levels are high or if clay and silt form the subgrade on which the tank bottom rests. Heaving causes cracks in the bottom and walls; therefore, leaving the tank in service is sometimes preferable to draining. However, if draining is necessary, the bottom should be protected with hay, straw, or other insulating material, or the tank should be alternately filled and emptied when it is out of service.

d. ICE THRUST. If a tank is removed from service and if water is left in to prevent flotation or frost heaving, take special precautions in cold climates to prevent formation of ice more than 6 inches thick; heavy ice develops a thrust on the tank's side walls which may cause serious damage. To prevent thrust—

(1) Cut a slot in the ice and keep it open.

(2) Insert logs along walls; they prevent thrust if ice is not too heavy.

e. FLOATING OF TANKS. Unless tanks are equipped with underdrain systems, anchored to piling, or otherwise designed to resist flotation, precautions are necessary to prevent floating of drained tanks which are subject to hydraulic uplift pressure; this pressure may affect tanks built on pervious strata or near a body of water. Tanks likely to be floated by ground water should not be drained unless the ground-water level is lowered by well points or ground-water valves within the tank.

12. Measuring Operating Temperatures

a. GENERAL. Equipment cannot be maintained properly unless limits of safe operating temperatures are known. If that information is not available, consult the manufacturer, giving him actual measured operating temperatures; judgment through touch cannot be relied on, especially when operating temperatures exceed 125° F. Data sent to the manufacturer include ambient temperature (temperature of air around the equipment), temperature of equipment, and location of the thermometer when taking the equipment temperature.

b. LIMITATIONS. Only external-surface temperatures can be taken. Thus, the only temperature measurement possible on motors is that of the surface of insulation; with bearings, the only possible measurement is temperature outside the boxing or bearing shell; and with transformers, the only possible measurement is temperature outside the case and, in some instances, the oil temperature.

c. TAKING MEASUREMENTS. Measure operating temperatures with a thermometer having a minimum of exterior fittings such as guards or mounts; an ordinary mercury thermometer, calibrated by the user for the range required, is satisfactory.

(1) Fasten thermometer to unit with adhesive tape so bulb is touching the surface whose temperature is being measured. Spread a ¼-inch thickness of glazier's putty around the thermometer bulb.

(2) Wait for thermometer reading to reach a constant value before recording temperature.

Note. If possible when measuring bearing temperatures, insert thermometer in inspection hole on top of bearing. Take care to position thermometer so it will not be broken. Do not use putty on the thermometer.

13. Power and Water Failure

Emergency power failures may disturb certain processes of water treatment or cause damage to equipment. To prevent this, prepare a list of actions in order of their importance, to be followed in case of sudden power interruptions; post the list centrally in each plant. Because water-cooled units or equipment using continuous water pressure may be damaged if water is shut off, precautions necessary in case of water failure must also be posted.

14. Equipment under Winter Conditions

Protecting operating and stand-by equipment against damage is especially important in cold climates. Make sure lubricants are changed to winter grades. Drain equipment temporarily out of use or on stand-by service to prevent water from freezing in confined places and bursting units such as the central housing of rotary distributors, pumps, and similar items.

15. Removing Equipment from Service

a. SHORT PERIOD. Precautions should be taken to prevent damage to equipment removed from service for a short period of time. Factors to be considered and precautions to be taken depend on the type of equipment and outside conditions. If the outage is likely to be long, turn the equipment over by hand or by motor weekly if possible.

b. PROTRACTED PERIOD. Special precautions are necessary for equipment which is to be out of service for long periods. Failure to retire or protect equipment may cause damage during idleness or on resumption of operation. Where it is known that the outage will be protracted, dismantle the equipment and protect it against corrosion and other damage by use of suitable greases, oils, and rust-preventive compounds (see par. 7 and tables III, IV, and V).

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

SECTION IV
DRIVING EQUIPMENT AND ACCESSORIES

16. Electric Motors

The post engineer's electrical staff is responsible for repairing motors. However, inspector mechanics or operators are responsible for the inspections in *a* and *b* below; in addition, the post engineer may make them responsible for services covered in *c*, *d*, and *e* below if they have the skill and the tools for the work required.

50 *a*. **Check Motor Condition.** (1) Keep motor free from dirt or moisture.

(2) Keep operating space free from articles which may obstruct air circulation.

(3) Check bearings for oil leakage.

51 *b*. **Note All Unusual Conditions.** Report any of the following to the post engineer for correction by the electrical staff:

(1) Unusual noises in operation.

(2) Motor failing to start to come up to speed normally. Sluggish operation.

(3) Motor or bearings which feel or smell hot.

(4) Continuous or excessive sparking at commutator or brushes. Blackened commutator.

(5) Intermittent sparking at brushes.

(6) Fine dust under coupling having rubber buffers or pins.

(7) Smoke, charred insulation, or solder whiskers extending from armature.

(8) Excessive hum.

(9) Regular clicking.

(10) Rapid knocking.

(11) Chatter in brush.

(12) Vibration.

(13) Hot commutator.

52 *c*. **Lubricate Bearings.** (1) Check oil level in sleeve bearings and replenish as needed. Use correct type and grade of oil (see table VI). See that oil ring operates freely.

53 (2) Check grease in ball or roller bearings and replenish when necessary with BR grease. Follow instruction below when preparing bearings for grease.

54 *d*. **Flush Antifriction Bearings.** The following is the approved method of flushing antifriction bearings on horizontal shafts equipped with drain plugs:

(1) Clean housihg and pressure-gun and relief fittings. Remove both fittings. Keep dirt out of bearings when greasing and cleaning. Once any abrasive is in a bearing it cannot be removed even by most thorough cleaning.

(2) Free old grease from relief plug hole in bottom of housing to permit easy removal of old grease after solvent is added.

(3) While motor is running, inject some grease solvent from a syringe into bearing housing through the pressure-fitting hole.

(4) Continue to add solvent until all grease has drained out through relief hole and clear solvent comes through.

(5) Replace relief plug and inject solvent until it can be seen in filling hole. Allow solvent to churn for a few minutes, then remove relief plug and drain. Repeat churning operation until solvent runs clear.

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

(6) If carbon tetrachloride is used, flush out solvent by replacing relief plug and injecting small amount of light lubricating oil. Allow to churn for 1 or 2 minutes before draining.

Note. Procedure may be slightly modified on motors where relief plug is not accessible.

54 *e.* **Refill Antifriction Bearings with Grease.** After cleaning, refill bearings with grease as follows (fig. 4):

(1) Clean pressure-gun fitting, bearing housing, and relief plug to make sure no dirt gets into bearing with the grease.

(2) Before using grease gun, remove relief plug from bottom of bearing to prevent excessive pressure in housing which might rupture bearing seals.

(3) Use clean screw driver or similar tool to remove hardened grease permitting excess grease to run freely from bearing.

(4) While motor is running, add grease with hand-operated pressure gun until it flows from relief hole, purging housing of old grease. If lubricating the running motor is dangerous, follow above procedure with motor at standstill.

(5) Allow motor to run long enough after adding grease to permit rotating parts of bearing to expel all excess grease from housing and prevent overgreasing.

(6) Stop motor and replace relief plug tightly with wrench.

† *f.* **Service Motor Controls.** See paragraph 16, TM 5–681.

17. Gasoline Engines

All gasoline engines (fig. 5) must be operated for at least 15 minutes each week, under load if practicable.

* *a.* **Before-Operation Service.** Make the following checks before putting engine in operation:

(1) **Check for tampering and damage.** Look for signs of tampering, damage, or injury, such as loosened accessories or drive belts.

(2) **Check fire extinguisher.** Check extinguishers for tight mountings, full charge, and closed valves. See that nozzles are not corroded.

(3) **Check fuel, oil, and water.** Check amount of fuel in tanks, noting signs of leaks or tampering. Add fuel if necessary. If fuel pipe is frozen, melt ice by wrapping pipe with cloth or waste soaked in hot water; *do not use open flame.* Check oil level and add oil if necessary. Check level and condition of coolant. During season when antifreeze is used, test coolant with hydrometer, and add antifreeze and water if necessary. Do not use alkali water.

Note. Investigate any appreciable change in fuel or water level since the last after-operation service and report it to proper authority.

(4) **Check accessories and drives.** Check all accessories such as carburetor, generator, regulator, starter, fan, shroud, and water pump for loose connections or mountings.

(5) **Check for leaks.** Look for signs of fuel, oil, water, or gear-oil leaks. Check cooling system for leaks, especially the radiator core and connecting hose. Check for leaks in engine crankcase, oil filters, oil tanks, oil coolers, and lines. Check fuel system for indications of leaks. Trace all leaks to their source and correct or report them to proper authority.

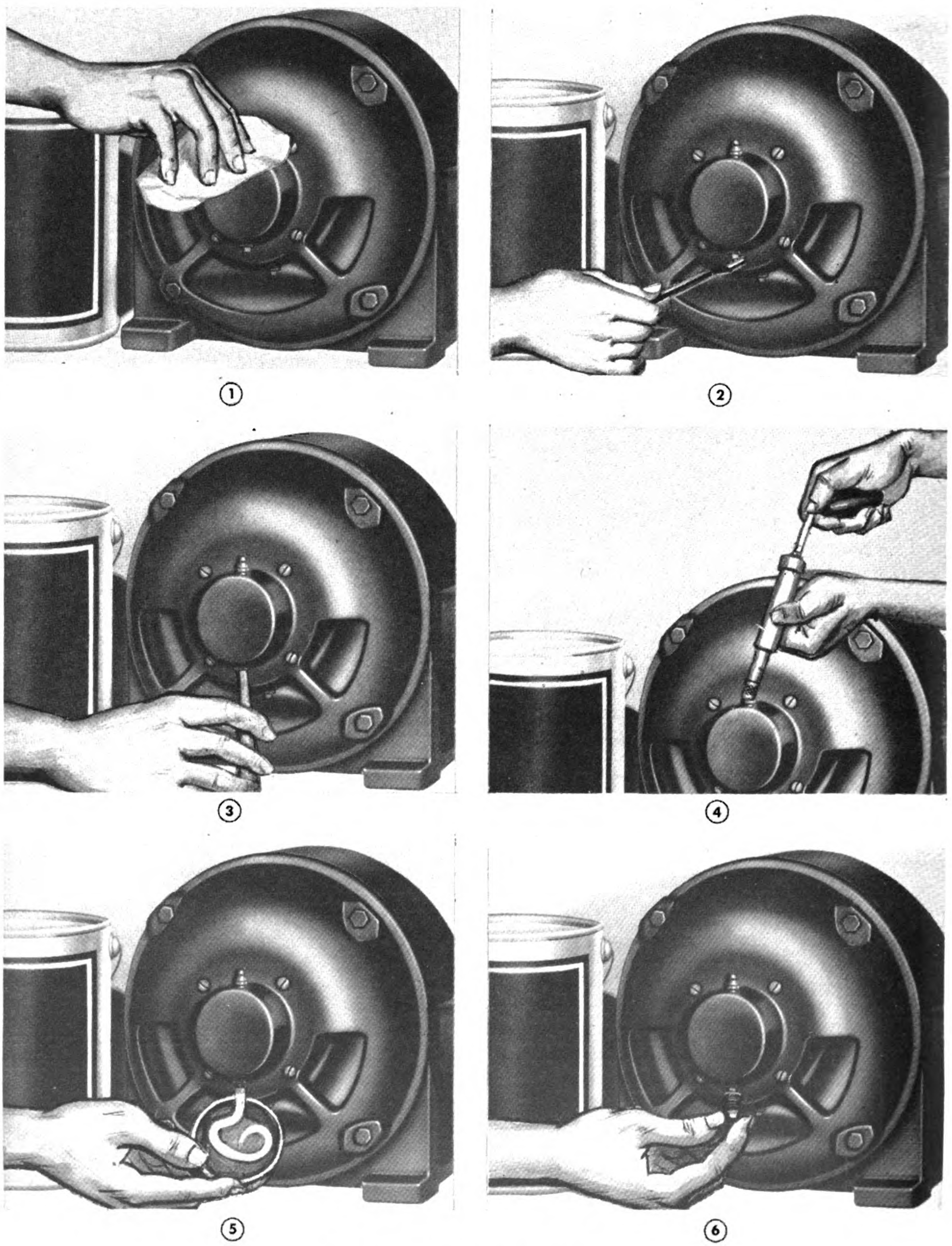
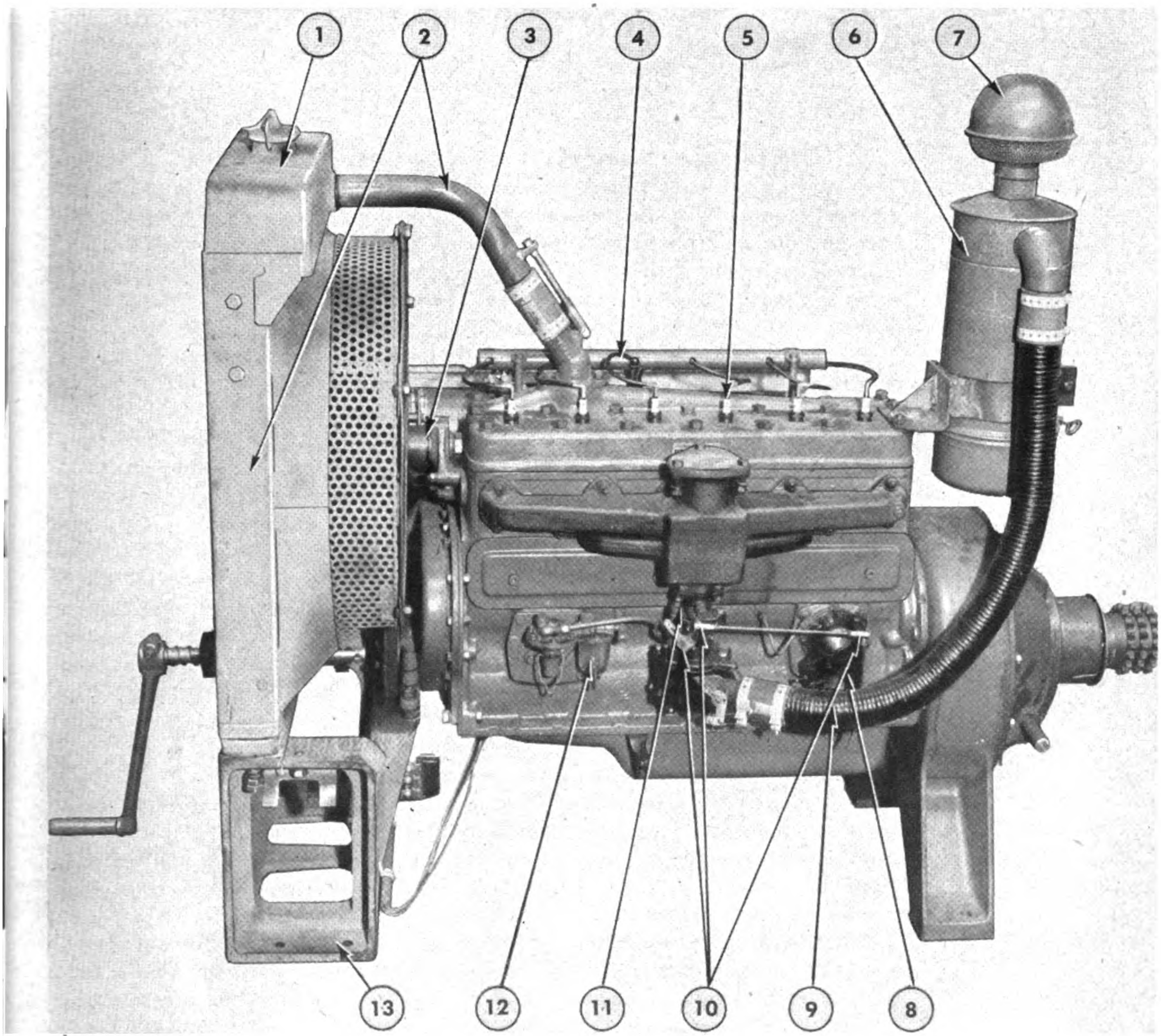


Figure 4. Refilling bearings with grease.



① *Radiator.*
② *Cooling system.*
③ *Water pump.*
④ *Ignition cables.*
⑤ *Spark plug.*
⑥ *Air cleaner.*
⑦ *Precleaner.*
⑧ *Distributor.*
⑨ *Air-cleaner pipe.*
⑩ *Control rod.*
⑪ *Carburetor.*
⑫ *Sediment trap.*
⑬ *Battery box.*

Figure 5. Stationary gasoline engine.

WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY

(6) **Observe engine warm-up.** Start engine and observe action of starter mechanism. See that starter has adequate cranking speed and engages and disengages properly without unusual noise. If oil-pressure gauge or signal light does not operate properly within 30 seconds, stop engine and correct trouble or report it to proper authority. Throttle engine to normal (fast idle) warm-up speed and continue servicing procedure. ***Caution:*** Great damage is caused by placing engine under load before reaching normal operating temperature.

(7) **Check choke or primer.** While starting engine, check operation of choker or primer. As engine warms up, reset choke to prevent overchoking and dilution of engine oil.

(8) **Check oil-pressure gauge or light indicator.** Observe operation of oil-pressure gauge or light indicator. If these instruments do not operate properly, stop engine immediately, investigate cause, and report it to proper authority. Do not let pressure drop below 10 psi at normal operating speed.

(9) **Check instruments.** *(a) Ammeter.* Ammeter should show a high charging rate for first few minutes after starting, until current used in starting is restored to the battery. After this period, ammeter should register zero or slight positive charge with accessories turned off and engine operating at fast idle. Investigate any unusual drop or rise in reading. An extended high reading may indicate a dangerously low battery or faulty generator regulator.

(*b*) *Tachometer.* Note whether tachometer indicates the approximate engine rpm.

(*c*) *Fuel gauge.* Observe fuel gauge for proper operation.

(*d*) *Voltmeter.* Check voltmeter for proper operation. It should register at least nominal battery voltage, usually indicated by a red line on instrument.

(*e*) *Temperature gauge.* Engine temperature should increase gradually during warm-up period. If temperature remains extremely low after a reasonable warm-up period, engine may need thorough check-up.

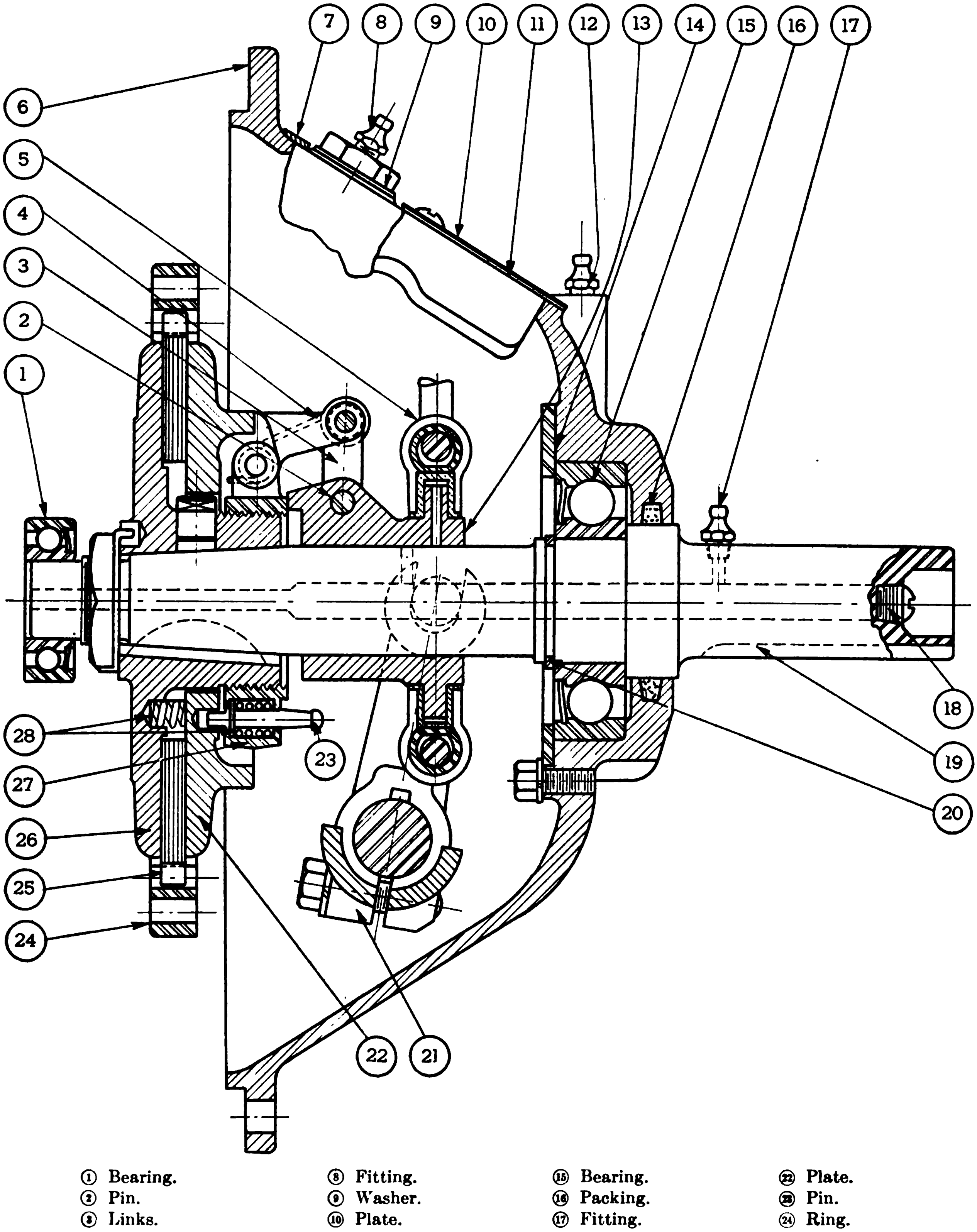
(10) **Check engine operation.** If temperature gauge does not indicate normal operating temperature but engine operates under load with the choke fully released and oil gauge indicates approximately normal operating pressure during engine acceleration, normal operating temperature may be assumed. Gradually accelerate engine several times after it has reached normal operating temperature, and investigate and correct any unusual noise or unsatisfactory operating characteristics.

* *b.* **During-Operation Service.** Make following checks during operation:

(1) **Check clutch.** See that clutch does not grab, chatter, or squeal during engagement or slip when fully engaged. If clutch lever does not have enough free travel before clutch begins to disengage, clutch may slip when under load. Too much free travel may keep clutch from disengaging fully, causing clashing gears and damage when shifting.

(2) **Check transmission.** See that gears shift smoothly, operate quietly, and do not creep out of mesh during operation. Gears jumping out of mesh may indicate wear in shifting mechanism or gear teeth, or incorrect alignment of transmission or clutch housing.

(3) **Check engine and controls.** Watch for poor engine performance such as lack of usual power, misfiring, unusual noise, stalling, overheating, or excessive exhaust smoke. See that engine responds to controls satisfactorily and that controls are correctly adjusted.



① Bearing.	⑧ Fitting.	⑮ Bearing.	㉒ Plate.
② Pin.	⑨ Washer.	⑯ Packing.	㉓ Pin.
③ Links.	⑩ Plate.	⑰ Fitting.	㉔ Ring.
④ Spring.	⑪ Gasket.	⑱ Plug.	㉕ Plate.
⑤ Collar assembly.	⑫ Fitting.	⑲ Shaft.	㉖ Clutch hub.
⑥ Housing.	⑬ Sleeve.	⑳ Ring.	㉗ Yoke.
⑦ Name plate.	⑭ Retainer.	㉑ Yoke.	㉘ Springs.

Figure 6. Twin-disk clutch and power take-off.

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY

(4) **Check instruments.** Observe all instrument readings frequently for proper operation. (See *a*(9) above.) Do not let oil pressure drop below 10 pounds at normal operating speed.

* *c*. **Short-stop Service.** Short-stop service is performed whenever the engine is stopped for a brief period. It includes correcting defects noted during operation and making the following inspections:

(1) **Check fuel, oil, and water.** (*a*) Make sure there is enough fuel to last through the contemplated shift operation. When refueling, use safety precautions for grounding static electricity. Allow space in filler neck for expansion. See that filler-vent caps are open and pressure-cap valves are free. Replace cap securely.

(*b*) Check crankcase oil level and add oil if necessary. Make sure oil drain is closed tightly.

(*c*) Remove radiator filler cap, being careful of steam, especially if a pressure cap is used. Check for proper level of coolant and replenish as necessary. Do not fill to overflowing, but leave enough space for expansion. If engine is hot, fill slowly while engine is running at a fast idle.

(2) **Check leaks.** See *a* (5) above.

(3) **Check accessories and belts.** See that fan, water pump, and generators are secure and their drive belts are adjusted and undamaged.

(4) **Check air cleaners.** When operating under extremely dusty conditions, inspect air cleaners and breather caps to see that they can deliver clean air properly. Service if necessary.

* *d*. **After-Operation Service.** When performing after-operation service, operators must consider any irregularities noticed during before-operation, during-operation, and short-stop services. Any engine requiring inspection or service while still at operating temperature should be inspected as soon as possible. After-operation service consists of making the following checks and correcting or reporting any deficiencies.

(1) **Check fuel, oil, and water.** See *c* (1) above.

(2) **Check engine operation.** See *a* (11) above.

(3) **Check instruments.** See *a* (9) above.

(4) **Check battery and voltmeter.** See that battery is not leaking and that battery, cables, and vent caps are clean and secure. Check voltmeter to see that it registers at least nominal battery rating, usually indicated by a red line on instrument.

(5) **Check accessories and belts.** Inspect carburetor, generator, regulator, starter, fan, shroud, water pump and other accessories for loose connections or mountings. Check adjustment of fan and accessory drive belts. Belts should deflect as specified in paragraph 18. Replace unserviceable belts.

(6) **Check electrical wiring.** Make sure all ignition wiring is securely connected, clean, and not damaged.

(7) **Check air cleaner and breather caps.** See that oil in air cleaner is at correct level. Rub a drop of oil between fingers. If it feels dirty, drain and refill with fresh oil. If operating in dusty area, remove and clean air cleaners and breather caps.

(8) **Check fuel filters.** Turn handle of Cuno type filters one complete turn. Check all fuel filters for leaks.

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

(9) **Check engine controls.** Check for worn or disconnected linkage. Correct or report any unsatisfactory engine-control linkage operation.

(10) **Check for leaks.** Locate all fuel, oil, or water leaks and correct or report them.

(11) **Check gear-oil levels.** Check level of lubricant in drives and transmissions after they have cooled at least enough to be touched by hand. Hot or foamy lubricant does not give a true lubricant-level indication.

e. **Additional Services.** Perform the following additional services weekly:

62 (1) **Check battery and voltmeter.** Clean dirt from top of battery. If terminal connections or posts are corroded, clean them thoroughly and apply thin coating of CG 1 grease. Tighten loose terminal bolts. Remove vent caps and check electrolyte level. Add water if required, taking precautions so battery will not be damaged by freezing. Battery should be secure and not bulging, cracked, or leaking electrolyte. If mountings are loose, tighten them carefully to avoid damaging battery case.

63 (2) **Check accessories and belts.** Tighten or adjust loose connections, linkage, or mountings of accessories. Examine all belts for fraying, wear, cracking, or presence of oil. (See par. 18.) Check all belts halfway between their pulleys to see whether tension is correct. Make necessary adjustments.

64 (3) **Inspect electrical wiring.** See that all accessible wiring is securely connected and supported, that insulation is not cracked or chafed, and that conduits and shielding are in good condition and secure. Report any unserviceable wiring.

65 (4) **Check air cleaners and breather caps.** Remove and disassemble air cleaners. Clean bodies and elements in kerosene After cleaning dry type air cleaner, oil sparingly with crankcase oil, drain, and replace. Do not allow oil in oil-bath cleaners to become excessively dirty or oil reservoir to get more than one-fourth full of sediment. Clean oil cup. Refill cup to proper level with same grade of crankcase oil. Wash out filter unit thoroughly with kerosene. Dry and reassemble. Reinstall air cleaners, giving special attention to mountings and alignment. Make sure all gaskets are in good condition and in place. If flexible steel tubing is used, wrap securely with tape and paint. See that all ducts connecting air cleaners to carburetors are secure and undamaged. Remove all breather caps and crankcase filter cleaning elements. Wash them thoroughly in kerosene, dip in crankcase oil, drain off excess, and reinstall. Clean and service oil-bath type breathers in the same way as oil-bath air cleaners.

66 (5) **Fuel filters.** Close shut-off valve to fuel line. Remove drain plug and drain water and sediment from filter bowl. Replace drain plug, tighten it securely, and reopen shut-off valve in fuel line. Make sure fuel is not leaking from drain plug. If filter has two plugs in bottom of bowl, the plug nearer the edge is for draining.

83 (6) **Lubricate.** (*a*) Drain oil from crankcase while engine is hot, and refill with new OE 10 or OE 30. See that oil drain is tightly closed. On stand-by service only, 64 hours of engine operation is considered as 1 week.

(*b*) Oil control-rod points. Lubricate control-rod points between carburetor and governor with OE 10.

(*c*) Check generator and starting motor. Fill generator oil cups with a few drops of OE 10.

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

f. **Running Test of Engine and Accessories.** The running test of engine and accessories requires careful, competent performance and provides more thorough maintenance. Checks requiring semiannual performance correspond to the 6,000-mile maintenance and technical inspection for Army vehicles.

1 (1) **Before-operation inspection.** Follow procedure given in *a* above.

3 (2) **Instruments and gauges.** (*a*) Oil. Observe oil gauge at frequent intervals under all engine speeds to see that oil pressure meets manufacturer's specifications and that viscometer reading is normal.

Caution: If gauge indicates zero or excessively low oil pressure, stop engine immediately and investigate cause.

(*b*) *Ammeter and voltmeter.* See *a* (9) above. Press voltmeter switch to see that voltage is properly indicated. Ammeter needle should show only slight fluctuation.

(*c*) *Tachometer.* Check tachometer for proper operation, excessive fluctuation, and unusual noises indicating faulty gears or cable.

(*d*) *Temperature.* See *a* (9) above. After warm-up, temperature should not normally exceed 180° F. Temperature above normal may indicate thermostat is stuck closed or that cooling system is clogged.

6 (3) **Clutch.** Clutch lever should have at least the minimum free travel recommended by manufacturer before meeting resistance other than the pull-back spring. Disengage clutch fully. If the transmission cannot be shifted into gear after a few seconds without clashing, clutch is dragging. Operate engine at various speeds and listen for noises indicating dry release bearings or defective release bearing, clutch plate, or pilot bearing. Any jerky motion or sudden engagement indicates chatter or grabbing.

9 (4) **Engine.** Observe following characteristics of engine operation:

(*a*) *Noises.* Listen for knocks and rattles as engine is accelerated and decelerated under light and heavy loads.

(*b*) *Acceleration and power.* Operate engine at various speeds to check for normal power and acceleration. Note any tendency to stall while shifting. A slight pinging during rapid acceleration is normal, continued or heavy pinging may indicate early timing, heavy carbon accumulation, or low-octane fuel.

(*c*) *Governed speed.* See that engine speed does not exceed the specified rpm.

(*d*) *Unusual noises.* Be alert for unusual noises indicating loose parts and damaged or improperly functioning units in the power train.

14 (5) **Leaks.** See *a* (5) above.

18 18 (6) **Engine head.** Inspect cylinder head and gasket. Look for cracks or oil, water, or compression leaks around studs, cap screws, and gasket. Make necessary corrections.

Caution: Cylinder heads should not ordinarily be tightened unless there are definite signs of looseness or leaks. If tightening is necessary, use a torque-indicating wrench and tighten in sequence to tension specified by manufacturer. When a new gasket is installed, tighten three times: on installation, again after engine is warmed up, and finally after final running test. On valve-in-head engines, adjust tappet clearance to specifications after final tightening of head nuts.

19 19 (7) **Valve mechanism.** (*a*) Examine valve-tappet clearances on valve-in-head engines while engine is hot. Valve tappets, rocker arms, and springs

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	
						should appear in good condition, correctly assembled, and secure. Oil should be delivered properly. See that valve cover gaskets are in good condition. Perform above service on L-head engines only when need is indicated by valve noises or engine performance.
				19		(*b*) Observe valve clearances and condition of valve mechanisms. Adjust clearances to specifications, taking care that lock nuts are secure when clearances are last checked during the adjustment.
		20				(8) **Spark plugs.** (*a*) Make sure spark-plug insulators are in good condition and clean, and no leakage is occurring around insulator or gaskets. Remove spark plugs and check for broken insulators, excessive carbon deposits, and electrodes which are burned thin. Replace unserviceable plugs. Report excessive deposits or damaged insulators which may be signs of incorrect heat range.
				20		(*b*) Clean deposits from the electrodes and insulators, and check again for cracks. If a plug cleaner is not available, install new or conditioned plugs.
				20		(*c*) Adjust gaps to specifications by bending to grounded electrodes. After completing item 21, reinstall plugs, using new gaskets. Take care not to overtighten them to avoid distortion and damage.
		21		21		(9) **Compression test and record.** With all spark plugs out, insert compression gauge in a spark-plug hole and rotate engine at cranking speed with the throttle wide open until maximum compression is indicated. Do not crank engine more than necessary to get maximum reading. Be sure battery is fully charged. Record reading on WD AGO Form 5–34. Repeat process for each cylinder. See manufacturer's instructions for specified compression pressures and variations due to altitude and wear. If pressure in cylinder is appreciably below normal, squirt enough engine oil on piston head to prevent loss of compression temporarily, then recheck. If low compression can be brought to normal by oil sealing, piston, ring, or cylinder wear or damage is indicated. If low compression is not brought to normal by this method, valve or gasket leakage is indicated.
		22		22		(10) **Battery.** (*a*) Inspect battery case for cracks or leaks. Clean top of battery. Inspect cables, terminals, bolts, posts, straps, and hold-downs for proper condition and record on service record. Specific gravity readings below 1.225 indicate battery should be recharged or replaced. Bring electrolyte to proper level by adding distilled water. Electrolyte level should be above top of plates and may extend ½-inch above them. Tighten terminals and hold-downs carefully to avoid damage to battery.
				22		(*b*) Perform high-rate discharge test. Follow instructions for condition test which accompany test instrument. Record voltage on service record; cell variation should not be more than 30 percent.
						Note. Specific gravity must be above 1.225 to make this test.
		23		23		(11) **Crankcase.** With engine idling, examine crankcase, valve covers, timing gear, and clutch housing for oil leaks. Stop engine; after oil has drained into crankcase, see that oil is at proper level.
						Note. If oil change is due, drain crankcase and refill to proper level with specified oil. Do not start engine until item 24 is completed.

WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	
	24				(12) **Oil filters, coolers, and lines.** (*a*) *Inspect oil filters, coolers, and all external engine-oil lines.* See that they are in good condition, secure, and not leaking.
					Note. When oil-filter cartridge change is due or its condition indicates need for change, remove filter cartridge, clean case, and install new cartridge of the correct type, using new gaskets and tightening cover securely.
	24				(*b*) *Clean disk type filters.* Turn handle one complete turn, remove drain plug, and drain contents.
			24		(*c*) *Clean and service filters.* Remove cover and element of disk type filters and clean them in kerosene without reassembling. Reinstall element if serviceable; if not, replace element or entire filter assembly.
	25				(13) **Radiator.** (*a*) See that radiator core, shell, shutters, mountings, hose, cap, gasket, overflow tank, and steam-relief tube and valve are in good condition, correctly assembled, securely mounted and connected, and do not leak. Make sure core air passages are not obstructed with dirt, insects, or trash. Look for badly bent core fins. See that steam-relief valve operates freely and is in correct position for prevailing atmospheric temperature. Examine coolant for rust, oil, or other foreign matter; clean cooling system if necessary. Before cleaning the system, drain radiator. If ethylene-glycol antifreeze is used, save drainings and pour back into radiator after radiator is cleaned. Clean cooling system according to current directives, using only specified cleaner. Flush cleaner from entire cooling system with clean water. Refill radiator with coolant, adding specified inhibitor unless new antifreeze containing inhibitor is used. Allow room at top for expansion. If antifreeze is in use, determine its protective value and record in space provided on service record.
	25		25		(*b*) Clean dirt from core with compressed air or stream of water applied carefully from the rear of core. DO NOT USE STEAM.
					Caution: If fins are bent, use only a suitably shaped piece of wood or blunt instrument to straighten them; otherwise tubes may be punctured.
	26		26		(14) **Water pump, fan, and shroud.** (*a*) Observe water pump to see that it is in good condition, not leaking, and securely installed. Loosen drive belts and leave them loose until item 29 is completed. Examine shaft for end play and loose bearings. Inspect fan blades to see that they are in good condition and properly secured to the hub. Make sure shroud is in good condition, properly aligned with fan, and securely mounted.
					(*b*) Tighten packing gland nut cautiously. Overtightening causes scoring of shaft and consequent leakage.
	27				(15) **Generator, starter, and switch.** (*a*) See that starter, generator, and switch are in good condition, securely mounted, and that wiring connections are clean and secure. Check condition and security of starter linkage and retracting spring. Remove generator and starter inspection covers and see that commutators and brushes are in good condition and not excessively worn; that brushes are free in holders and have enough spring tension to hold them in contact with commutator; and that brush-connecting wires are secure and not chafing.
			27		(*b*) Clean commutator end of generator and starter with compressed air. If commutator is dirty, clean with fine (00) sandpaper. Blow out dust with compressed air.

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	
				27		(*c*) Tighten starter mounting bolts.
		29		29		(16) **Drive belts and pulleys.** Check all drive belts for fraying, excessive wear, and deterioration. See that all drive pulleys and hubs are in good condition and securely mounted. Adjust all accessory drive belts to specified tension.
		30		30		(17) **Tachometer drive and adapter.** See that tachometer drive and adapter are in good condition, correctly assembled, and secure. Inspect flexible drive shaft connection for oil leaks.
		31				(18) **Distributor.** (*a*) See that distributor body and external attachments are in good condition and secure.
						1. Blow or wipe dirt or dust from distributor cap. Remove cap and see that cap, rotor, and breaker-plate assembly are in good condition, correctly assembled, secure, and serviceably clean. Pay particular attention to cracks in cap and rotor, corrosion of terminals and connections, and to burning of outer ends of the conductor strap of the rotor.
						2. See that breaker points are in good condition, well aligned, and adjusted to manufacturer's specifications.
						3. If breaker-plate assembly is unserviceably dirty, remove distributor, clean in kerosene or dry-cleaning solvent, dry with compressed air, lubricate parts as shown in item 31, and reinstall in correct position for timing.
						4. When cleaning distributor, remove wick and lubrication cup, clean and dry them, and reinstall only after distributor assembly is cleaned and blown dry with compressed air.
						5. If breaker points are pitted, burned, or worn to unserviceable condition, install a new set of points. If points are badly pitted, replace condenser, which probably caused the pitting.
						6. Install new points so they are well aligned and engage squarely.
						7. If points are slightly pitted or burned, dress them with an American-Swiss No. 6 file or equivalent, or with 00 sandpaper; do not use emery cloth. Remove filings with compressed air.
				31		(*b*) Check tightness of shaft by hand to determine whether distributor camshaft is excessively worn in its bushings.
						(*c*) See that vacuum-advance mechanism and its vacuum lines are in good condition, correctly assembled, and secure; that vacuum-advance mechanism can be moved by finger force through its normal movement; that diaphragm spring returns mechanism to original position when finger force is removed; and that mechanism does not bind or hang up during this check.
		31		31		(*d*) Wipe breaker cam lightly with CG 1 and lubricate breaker-arm pivot and wick under rotor with 1 to 2 drops of SAE 30. Take care to keep lubricant away from distributor points, to apply no more lubricant than specified, and to wipe cam clean before lubricating its surfaces.
				31		(*e*) Adjust breaker-point gap according to manufacturer's instructions.
		32		32		(19) **Coil and wiring.** See that coil is in good condition, clean, and securely mounted. All high-voltage ignition wiring, including shielding of conduits, should be in good condition and securely fastened to all support mountings

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DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	
						and terminals. See that all insulation and connections are clean. Inspect all low-voltage wiring in engine compartment in same manner. *Note.* Do not tighten wiring connections unless they are actually loose because over-tightening terminals causes damage.
		33				(20) **Manifolds and heat control.** (*a*) See that intake and exhaust manifolds are in good condition, secure, and that manifold gaskets are in good condition and not leaking. Make sure the control-adjusting pointer on a manually operated manifold heat control is set at correct seasonal position. If control is automatic, see that bimetal control spring is in good condition and securely connected to heat-control valve shaft and mounting, that shaft operates freely, and that spring controls shaft and valve properly.
				33		(*b*) Tighten all manifold assembly, mounting, exhaust pipe, and carburetor connecting flange nuts evenly and securely.
		34		34		(21) **Air cleaners.** (*a*) Remove all air-cleaner elements. See that all gaskets, seals, clamps, and connecting hose or tubes are present and in good condition. Observe condition of cleaning elements, baffles, and body. Check level and cleanliness of oil in reservoir of oil-bath cleaners.
		34		34		(*b*) Refill with OE 30. Install air cleaner, being careful to press it firmly into place. See that mounting is secure. If air cleaner has an external air baffle, see that it is correctly aligned with air stream from fan. Make sure connecting hose is in good condition and properly clamped to air cleaner.
		35		35		(22) **Breather caps and ventilators.** See that breather caps and ventilators are in good condition, correctly assembled, secure, and that ventilator tubes are open.
		36		36		(23) **Carburetor, choke, throttle, linkage, and governor.** See that carburetor, choke, throttle, linkage, and governor are in good condition, correctly assembled, and securely installed; that carburetor does not leak; that control linkage, including choke and throttle shaft, is not excessively worn; that choke valve opens fully when control is in released position; that throttle valve opens fully when accelerator is fully depressed; and that governor is secure and properly sealed.
		37		37		(24) **Fuel filters, screen, and lines.** (*a*) Examine all fuel filters and sediment bowls, fuel lines, and connections to make sure they are in good condition, secure, and not leaking.
						(*b*) Close fuel shut-off valve and remove filter bowls, gaskets, and filter elements or screens. Without disassembling disk type filters, clean filter elements, sediment bowls, and screens in kerosene. Dry elements thoroughly, including any screen or filter element at carburetor fuel-line connection or at fuel pump. Reinstall removed parts, using new gaskets. Turn on fuel shut-off valve after assembling, and recheck for leaks. *Note.* If filter element or screen is damaged or clogged beyond cleaning, replace it.
		38				(25) **Fuel pump.** (*a*) See that fuel pump and lines are in good condition, secure, and not leaking.
					38	(*b*) Attach a fuel-test gauge and, with engine idling, note that pump pressure is within limits specified by manufacturer. Replace any pump that does not produce proper pressure, being sure to make a similar check of new pump.
		39		39		(26) **Starter.** Inspect starter for action, noise, and speed. Start engine, noting whether general action of starter is satisfactory, particularly whether it engages and operates properly without excessive noise. Check to see that

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	
						starter has adequate cranking speed and that engine starts readily. As soon as engine starts, see that oil-pressure gauge and ammeter indications are satisfactory.
		40		40		(27) **Leaks.** See *a* (5) above.
		41		41		(28) **Ignition timing.** With engine running and neon timing light connected, observe ignition timing. See that automatic controls advance timing as engine is accelerated gradually. Adjust timing to conform with manufacturer's instructions.
		42		42		(29) **Engine idle and vacuum test.** (*a*) See that engine operates smoothly at normal idling speed. Connect vacuum gauge to intake manifold, adjust engine to normal idling speed by throttle stop screw, and adjust idling mixture adjusting needle until vacuum gauge indicates steady maximum reading. If latter adjustment changes idling speed appreciably, reset idling speed and mixture until both are satisfactory. Time can be saved by making both adjustments simultaneously.
				42		(*b*) Make vacuum test. With engine running at normal idling speed, vacuum gauge should read about 18 to 21 inches and pointer should be steady. A needle fluctuating badly between 10 and 15 inches may indicate a defective cylinder-head gasket or valve. An extremely low reading may indicate a leak in intake manifold or gasket. Accelerate and decelerate engine quickly. If gauge indicator fails to drop to about 2 inches as throttle is opened and fails to recoil to at least 24 inches as throttle is closed, diluted oil, poor piston-ring sealing, or abnormal restriction in the carburetor, air cleaner, or exhaust may be indicated.
						Note. The above readings apply to sea level. They are about 1 inch less for each 1,000 feet of altitude.
		43				(30) **Regulator unit.** (*a*) See that regulator unit is in good condition and that connections, seals, and mountings are secure.
				43		(*b*) Connect low-voltage circuit tester and see that voltage regulator, current regulator, and cut-out control the generator output properly. Follow instructions which accompany test instrument. Replace if test shows faulty operation.
						Caution: This test should be made only after regulator unit has reached normal operating temperature.
			44			(31) **Gasoline tank.** Drain gasoline to prevent gumming of carburetor and fouling of engine by deteriorated gasoline. Refill tank with fresh gasoline. If carburetor and engine are gummed, remove deposits with acetone or alcohol. If gum has dried, use of solvent may not be satisfactory and scraping may be necessary to remove gum.
		45				(32) **Flexible-shaft universal joints and spline.** Every 256 hours of operation of stand-by engines, force GO 90 into Zerk fittings at shaft points.
				46		At 1,024-hour intervals, disassemble, clean in solvent, and lubricate all fittings with GO 90.
				47		(33) **Power take-off clutch pilot bearings and shaft-bearing throw-out collar.** Every 8 hours of operation of stand-by engine, lubricate bearings and collar with WB 2 grease.
						g. **Record Keeping.** Enter all services performed on gasoline engine on WD AGO Form 5–34. It is recommended that forms be made out as follows:
						(1) One card for *before-operation service* (*a* above).
						(2) One card for *during-operation service* (*b* above).

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

(3) One card to include *short-stop service*, *after-operation service*, and *additional services* (*c*, *d*, and *e* above).

(4) Two cards for *running test of engine and accessories*, one for items in *f* (1) through (16) above, and a second for items in *f* (17) through (33) above.

18. Belt Drives

a. General. Maintaining proper tension and alignment of belt drives insures long life of belts and sheaves. Incorrect alignment causes poor operation and excessive belt wear. Inadequate tension reduces the belt grip and causes high belt loads, snapping, and unusual wear.

(1) *Cleaning belts*. Keep belts and sheaves clean and free of oil, which causes belts to deteriorate. To remove oil, take belts off sheaves and wipe belts and sheaves with a rag moistened in carbon tetrachloride.

(2) *Installing belts*. Before installing belts, replace worn or damaged sheaves, then slack off on adjustments. Do not try to force belts into position; never use a screw driver or similar lever to get belts onto sheaves. After belts are installed, adjust tension; recheck tension after 8 hours of operation.

(3) *Replacing belts*. Replace belts as soon as they become frayed, worn, or cracked. NEVER REPLACE ONE V-BELT ON A MULTIPLE DRIVE. Replace the complete set with a set of matched belts, which can be obtained from any supplier. All belts in a matched set are machine-checked to insure equal size and tension.

(4) *Storing spare belts*. Store spare belts in a cool dark place. Tag all belts in storage to identify them with the equipment on which they can be used.

b. V-belts. A properly adjusted V-belt has a slight bow in the slack side when running; when idle, it has an alive springiness when thumped with the hand. An improperly tightened belt feels dead when thumped. If the slack side of the drive is less than 45° from the horizontal, vertical sag at the center of the span may be adjusted in accordance with table VII.

Vertical drives, extremely short-center drives, and drives carrying pulsating loads need about 10 percent more tension.

Table VII. Belt tension

Span (inches)		10	20	50	100	150	200
Vertical sag (inches)	From	.01	.03	.20	.80	1.80	3.30
	To	.03	.09	.58	2.30	4.90	8.60

2 (1) **Check tension.** If tightening belt to proper tension does not correct slipping, check for overload, oil on belts, or other possible causes. Never use belt dressing to stop belt slippage. Rubber wearings near the drive are a sign of improper tension, poor alignment, or damaged sheaves.

3 (2) **Check sheave alignment.** Lay a long straightedge or string across outside faces of pulleys, and allow for difference in dimensions from center lines of grooves to outside pulley faces of the pulleys being aligned.

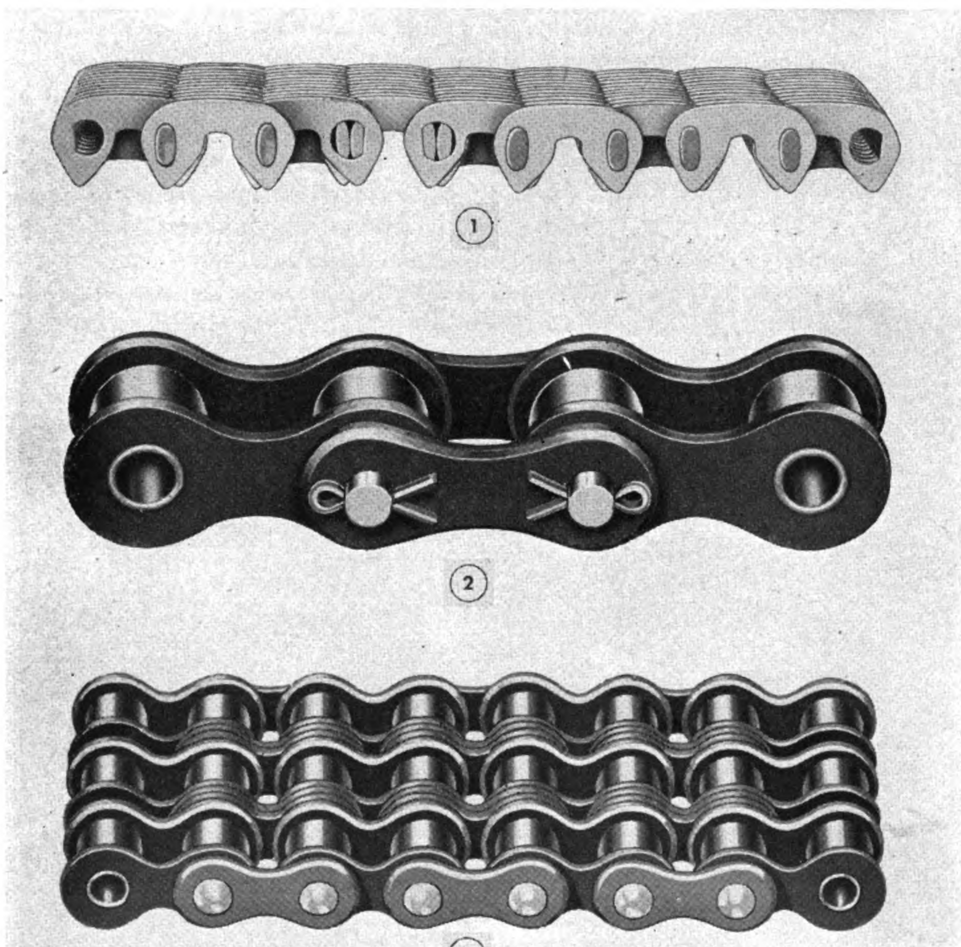
c. **Flat Belts.** Leather or rubber belts are usually used in flat-belt drives. Most flat-belt drives have either an adjustable idler or a pivoted-base drive motor to maintain belt tension.

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	
1						(1) **Check operation and tension.** Check general operating conditions during regular tours of duty. Keep surroundings clean. Observe belt tension and adjust if necessary. Slapping and whipping are evidences of improper tension. If a rubber flat belt slips after tension has been properly adjusted, moisten pulley side of belt lightly with boiled linseed oil. To keep leather belts from slipping, use belt dressing type B, class 14 TPS, stock No. 14–B–155, available in stick form; never use rosin on leather belts.
		4				(2) **Check alignment.** Check pulley alignment with straightedge or string and make necessary corrections.

19. Chain Drives

a. General. Chain drives may be designed for slow, medium, or high speeds.

(1) *Slow-speed drives.* Because slow-speed drives (fig. 7) are not usually inclosed, adequate lubrication is difficult. Heavy oil applied to the outside of the chain seldom reaches the working parts; in addition, the oil catches dirt



① Silent chain drive. ② Single-roller chain. ③ Triple-roller chain.

Figure 7. Types of chain drives.

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

and grit and becomes abrasive. For lubricating and cleaning methods, see *e* and *f* below.

(2) *Medium- and high-speed drives.* Medium-speed drives should be continuously lubricated with a device similar to a sight-feed oiler. High-speed drives should be completely inclosed in an oiltight case and the oil maintained at proper level. Lubricate roller chains with NS 2075 or NS 3065.

1 *b.* **Check Operation.** Check general operating condition during regular tours of duty.

2 *c.* **Check Chain Slack.** The correct amount of slack is essential to proper operation of chain drives. Unlike other belts, chain belts should not be tight around the sprocket; when chains are tight, working parts carry a much heavier load than necessary. Too much slack is also harmful; on long centers particularly, too much slack causes vibrations and chain whip, reducing life of both chain and sprocket. A properly installed chain has a slight sag or looseness on the return run. Make sure a tightener is installed on the drive chain; if there is none, notify the post engineer.

3 *d.* **Check Alignment.** If sprockets are not in line or if shafts are not parallel, excessive sprocket and chain wear and early chain failure results. Wear on inside of chain, side walls, and sides of sprocket teeth are signs of misalignment. To check alignment, remove chain and place a straightedge against sides of sprocket teeth.

4 *e.* **Clean.** On inclosed types, flush chain and inclosure with kerosene. On exposed types, remove chain and soak and wash it in kerosene. Clean sprockets, install chain, and adjust tension.

Note. If chains are too large to soak them conveniently, wash them by applying gasoline with a brush.

5 *f.* **Check Lubrication.** Lubricate inclosed and exposed type chain drives as shown in table VI. Soak exposed type chain in CW 2 or in OE 30 to restore lubricating film. Remove excess lubricant by hanging chains up to drain.

Do not lubricate underwater chains which operate in contact with considerable grit. If water is clean, lubricate by applying WP or GG grease with brush while chain is running.

Do not lubricate chains on elevators or on conveyors of feeders which handle dirty or gritty materials. Dust and grit combine with lubricants to form a cutting compound which reduces chain life.

6 *g.* **Change Oil.** On inclosed types only, drain oil and refill case to proper level.

7 *h.* **Inspect.** Note and correct abnormal conditions before serious damage results. Do not put a new chain on old sprockets. Always replace sprockets when replacing a chain, because old, out-of-pitch sprockets cause as much chain wear in a few hours time as years of normal operation. Frequently, additional chain life can be secured by turning the chains over. Sprockets that are not too badly worn can be reversed on the shaft and the opposite surface of the tooth brought into use. Where the direction of rotation can be changed without affecting operation of the driven equipment, the simple expedient of reversing electrical leads on the motor increases the life of chain drives appreciably.

i. **Trouble Shooting.** Some common symptoms of improper chain-drive operation and their remedies follow:

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY

(1) *Excessive noise.* Correct alignment, if misaligned. Adjust centers for proper chain slack. Lubricate in accordance with aforementioned methods. Be sure all bolts are tight. If chain or sprockets are worn, reverse or renew if necessary.

(2) *Wear on chain, side walls, and sides of teeth.* Remove chain and correct alignment.

(3) *Chain climbs sprockets.* Check for poorly fitting sprockets and replace if necessary. Make sure tightener is installed on drive chain. Cause may also be severe overload.

(4) *Broken pins and rollers.* This may be caused by shock loads or chain speed which is too high for the pitch. If due to the latter, use chain of shorter pitch.

(5) *Chain clings to sprockets.* Check for incorrect or worn sprockets or heavy tacky lubricants. Replace sprockets or lubricant.

(6) *Chain whips.* This may be caused by too long centers or by high pulsating loads which should be corrected.

(7) *Chain gets stiff.* Check and correct alignment and lubrication; excessive overloads may also cause this condition.

20. Right-angle Gear Drives

82 *a.* **Check Lubricant Flow.** Immediately after starting a right-angle gear drive (figs. 8, 9, and 10), remove inspection plate of gear drive and check for proper flow of lubricant. If there is no flow, stop motion and check for mechanical defect. If no mechanical defect is found, changing lubricant or draining and warming old lubricant may be necessary.

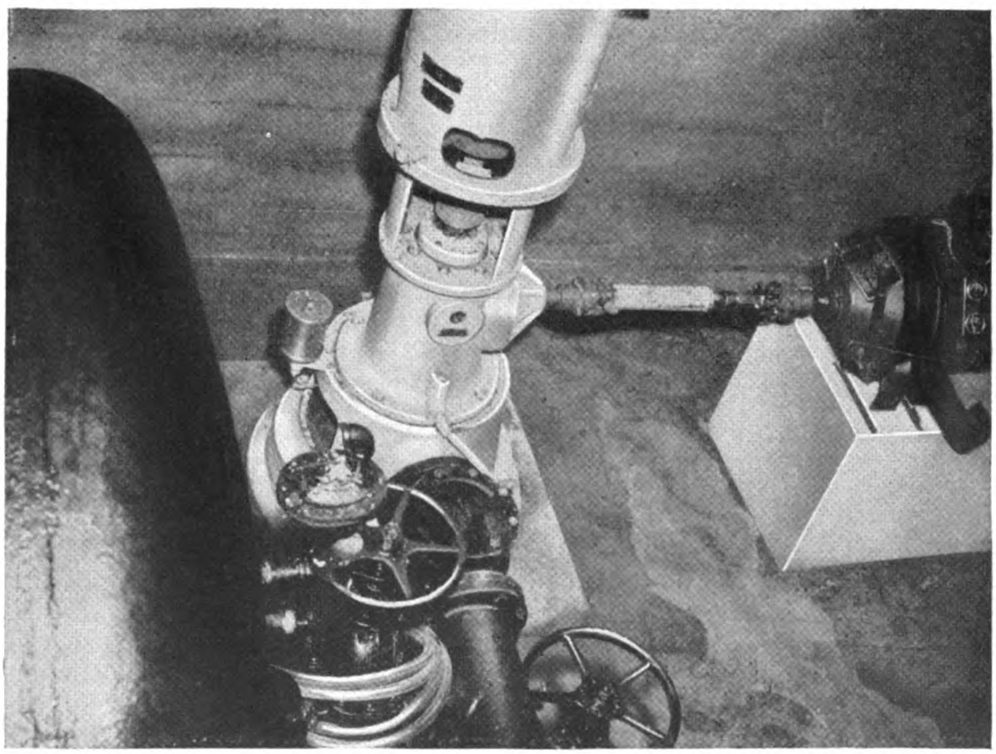
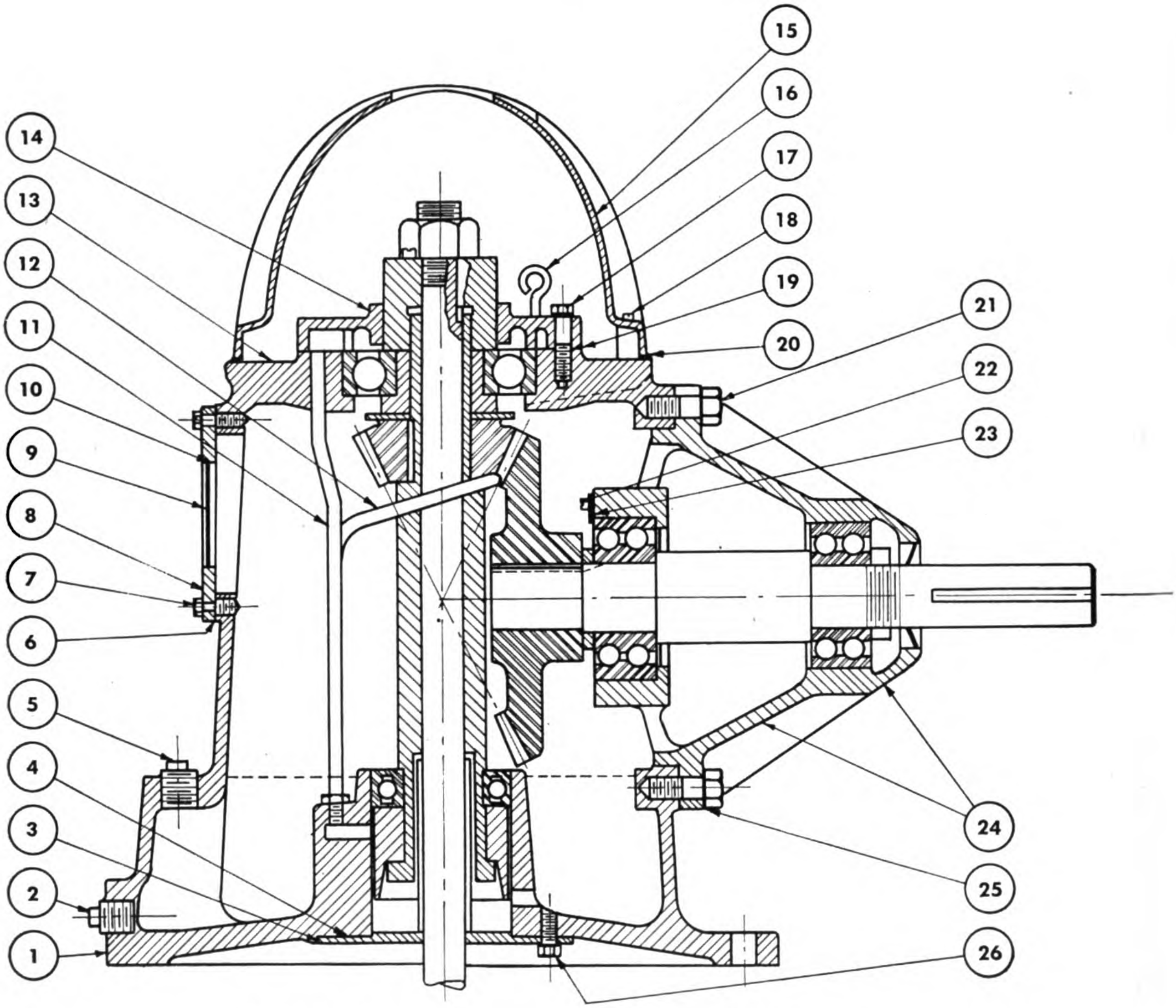
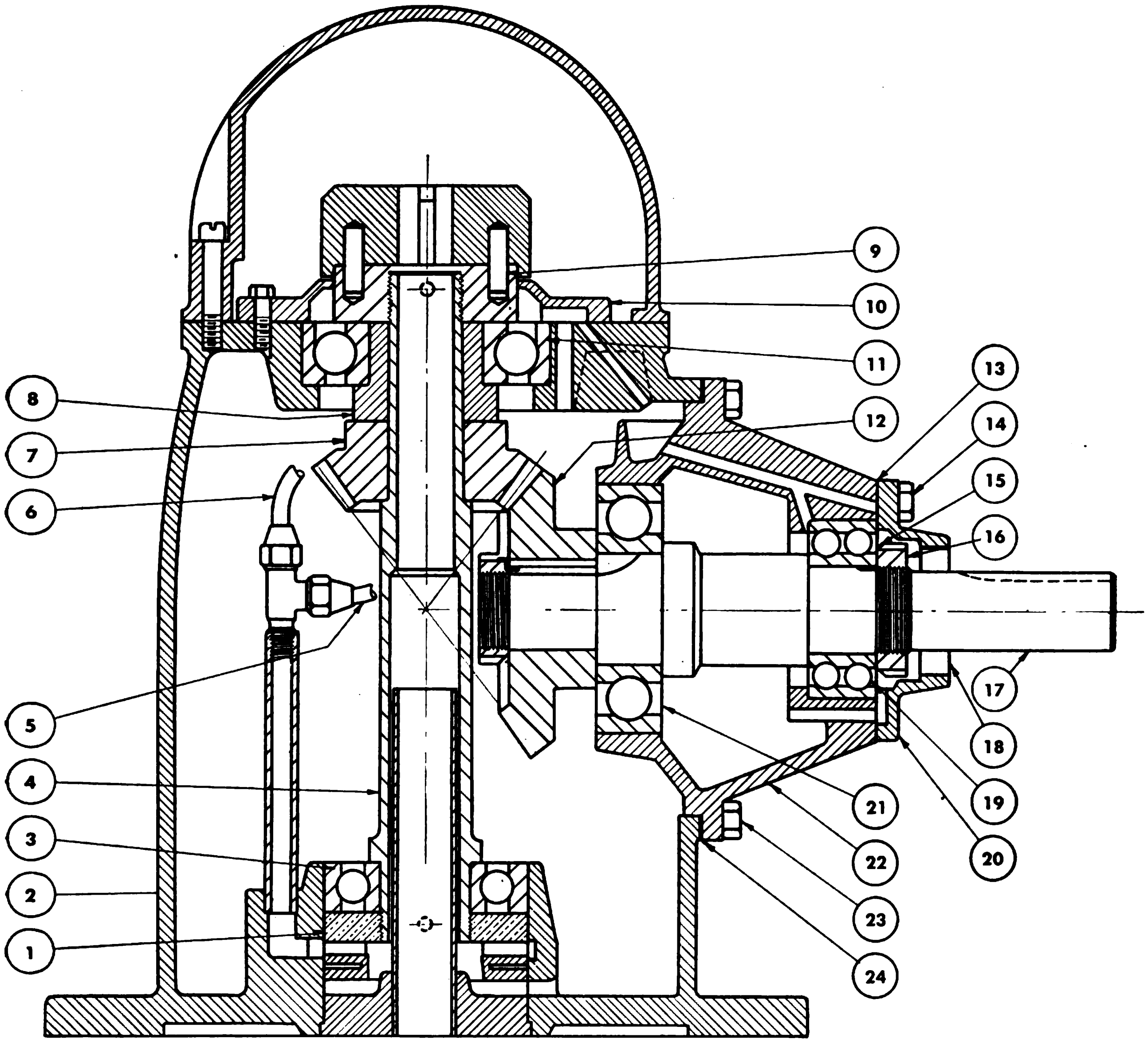


Figure 8. Right-angle drive, flexible-shaft universal joints, and power take-off for deep-well pump (guard removed).



① Housing.
② Plug.
③ Tube.
④ Gasket.
⑤ Plug.
⑥ Gasket.
⑦ Screw and washer.
⑧ Plate.
⑨ Glass.
⑩ Gasket.
⑪ Tube.
⑫ Tube.
⑬ Housing.
⑭ Cover.
⑮ Dome.
⑯ Bolt.
⑰ Screw and washer.
⑱ Screw.
⑲ Gasket.
⑳ Gasket.
㉑ Screw and washer.
㉒ Screw and washer.
㉓ Washer.
㉔ Housing.
㉕ Gasket.
㉖ Screw and washer.

Figure 9. Johnson right-angle gear drive.



(1) Oil-pump impeller.
(2) Gear housing.
(3) Vertical-shaft and radial bearing.
(4) Vertical shaft.
(5) Gears oil line.
(6) Thrust-bearing oil line.
(7) Gear.
(8) Vertical-shaft spacer.
(9) Driving nut.
(10) Thrust-bearing cover.
(11) Vertical-thrust bearing.
(12) Gear.
(13) Gasket.
(14) Cap screws.
(15) Lockwasher.
(16) Locknut.
(17) Horizontal shaft.
(18) Oil seal.
(19) Horizontal-shaft thrust bearing.
(20) Oil-cap seal.
(21) Horizontal-shaft radial bearing.
(22) Horizontal-shaft carrier.
(23) Cap screws.
(24) Gasket.

Figure 10. Amarillo right-angle gear drive.

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

87 *b.* **Drain and Change Lubricant.** To minimize detrimental effects of possible water-oil emulsion, refill with fresh lubricant about every 500 hours of operation. Use NS 3080 or NS 5190, depending on prevailing air temperatures.

21. Variable-speed Drives

83 *a.* **Clean Disks.** Remove grease, acid, and water from disk faces.

84 *b.* **Check Speed-change Mechanism.** Shift drive through entire speed range to make sure shafts and bearings are lubricated and disks move freely in lateral direction on shafts.

85 *c.* **Check V-belt.** Make sure it runs level and true. If one side rides high, a disk is sticking on shaft because of insufficient lubrication or wrong lubricant. In that case, stop drive at once, remove V-belt, and clean disk hub and shaft thoroughly with kerosene until disk moves freely. Relubricate with soft ball-bearing grease and replace V-belt in opposite direction from that in which it formerly ran.

88 If drive is not operated for 30 days or more, shift unit to minimum speed position, placing spring on variable speed shaft at minimum tension and relieving belt of excessive pressure.

d. **Lubricate Drive.** Make sure to apply lubricant at all the six force-feed lubrication fittings and the one cup type fitting. Use BR grease.

86 (1) Once every 10 days to 2 weeks, use two or three strokes of grease gun through force-feed fittings at ends of shifting screw and variable shaft to lubricate bearings of movable disks. Then shift drive from one extreme speed position to the other to attain thorough distribution of lubricant over disk-hub bearings.

89 (2) Add two or three shots of grease through force-feed fittings which lubricate frame bearing on variable speed shaft.

90 (3) Every 60 days, add 2 or 3 cupfuls of grease to grease cup which lubricates thrust bearing on constant speed shaft.

91 (4) Every 60 days, use two or three strokes of grease gun through force-feed fittings on motor-frame bearings. Do not use hard grease or grease containing graphite.

92 *e.* **Lubricate Reducer.** When unit leaves factory, gear reducer is without oil. Fill reducer case with oil described below until it drains out of oil plug. The reducer is provided with splash type self-lubrication and oil supply is replenished only when it gets low. Check oil level every 60 days by removing oil-hole plug. For temperatures of 0° F. to 40° F., use NS 2075. For temperatures of 40° F. to 100° F., use NS 3080.

22. Gear Reducers, Gear Motors, and Speed Changers

There are too many types and varieties of gear reducers, gear motors, and speed changers to give specific maintenance information for all of them. The preventive maintenance operations below should be adequate for most types; to insure satisfactory maintenance, check this list against manufacturer's recommendations and supplement it where necessary.

a. **Flooded Lubrication Types.** Flooded lubrication types do not require annual overhaul because they usually consist of completely inclosed oil-lubricated gears and bearings which operate under ideal conditions. In general,

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

dismantling causes more harm than good because it may result in damage to oil seals, allowing dirt and dust to enter and injure parts. If a particular unit has parts which obviously need annual overhaul, or if annual overhaul is recommended by the manufacturer, include that operation in the preventive maintenance program. For normal maintenance—

1 [Daily] (1) **Check general operation.** Note general operating conditions during regular tours of duty. Observe oil level, oil-flow indication gages, oil rings, etc. Keep unit and surroundings clean.

(*a*) *Operating sound.* Listen for unusual operating sounds, generally a sign of trouble.

(*b*) *Alignment.* Keep units properly aligned with driving and driven equipment.

(*c*) *Temperature.* Make sure there is enough air circulation for adequate cooling. Check operating temperature by touch; learn to recognize normal operating temperature. Investigate cause of any variation from normal.

3 [Weekly] (2) **Lubricate and inspect.** Check oil level and add oil if necessary. Clean unit thoroughly. Tighten all loose nuts and bolts.

4 [Semiannually] (3) **Change oil.** See paragraph 7 and table VI for correct lubricant.

5 [Annually] (4) **Inspect.** Thoroughly examine unit for oil leaks, rust, or deterioration. Paint if necessary. Flush unit internally with kerosene and drain carefully. *If thorough draining is not possible, flush with light mineral oil.* After flushing, add oil to proper level. Observe unit in operation to detect mechanical faults.

b. WITHOUT FLOODED LUBRICATION. Gear reducers, gear motors, and speed changers which do not have flooded lubrication systems are maintained as follows:

* [Annually] (1) **Lubricate.** Frequency of lubrication depends on service conditions; weight of lubricant used depends on loads involved. Determine correct lubricant and frequency of application by trial and error, using lubricant which maintains a grease film longest.

Use lubricant heavy enough to stay on gears. Test its effectiveness by seeing whether a grease film remains on contact points after teeth have meshed. Heavy compounds (par. 7) are suitable for severe conditions. They produce considerable drag and are limited to heavy equipment. They must be applied to clean metal, so gears must be cleaned with kerosene before the compounds can be applied. In case of doubt on proper lubricant, consult the post engineer.

2 [Daily] (2) **Check general operation.** Observe operating condition during regular tours of duty. Make sure gears are well lubricated and free from abrasing dirt.

6 [Annually] (3) **Check alignment and clean.** Check fit of gears to be sure they are not loose. Check alignment by observing how teeth mesh; a feeler gauge can be used. Align gear faces with straightedge on string. Make sure gear teeth do not touch bottoms of grooves when they turn. Check wear. Wash thoroughly with kerosene, and relubricate.

23. Ball, Roller, Sleeve, Thrust, and Underwater Bearings

Properly designed bearings give trouble-free performance if they are regularly inspected, properly lubricated, and scrupulously cleaned. Do not lubricate presealed bearings. (See TM 37-265.)

WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

6 *a.* **Check Temperatures.** Bearings may normally operate at temperatures too hot to be touched by the hand. However, when bearing temperature is considerably higher than surrounding temperatures (high ambient temperature) serious trouble may result. In cases of overheating, check for misalignment, excessive overload, overlubrication, and improper lubricant. Consult manufacturer if cause cannot be determined. Cool to safe temperature with a fan while taking remedial steps. Ball or roller bearings operate safely up to and over 200° F. Oil-ring type babbitted sleeve bearings operate safely up to 160° F.

b. **Check for Vibration.** Determine and eliminate cause of vibration, which is often a source of trouble.

16 *c.* **Lubricate and Inspect.** (1) *Ball and roller bearings.* Use as light a lubricant as ball or roller bearings can retain because contacting parts need only a film of oil or grease. Do not use pressure gun to grease an antifriction bearing which has no relief hole. Use BR grease, or oils listed in paragraph 7. Repacking bearings annually is adequate if seals do not leak grease.

17 (2) *Equipment annually overhauled.* If equipment is annually overhauled, disassemble unit and flush bearings with kerosene. Observe proper precautions against fire hazards. After flushing, dip bearings in clean oil. Be extremely careful of dust and dirt by laying parts on newspapers and using clean rags. Remove bearings with a press if available. Never use pressure applied through balls or rollers. Do not add more than one-third the volume of the housing when repacking, unless otherwise specified by the manufacturer. Add oil to proper level on oil-lubricated bearings.

18 (3) *Equipment not annually overhauled.* Inspect for bearing looseness all equipment not annually overhauled.

7 (4) *Oil-lubricated bearings.* Drain and flush housing of oil-lubricated bearings with kerosene. Add oil to proper level.

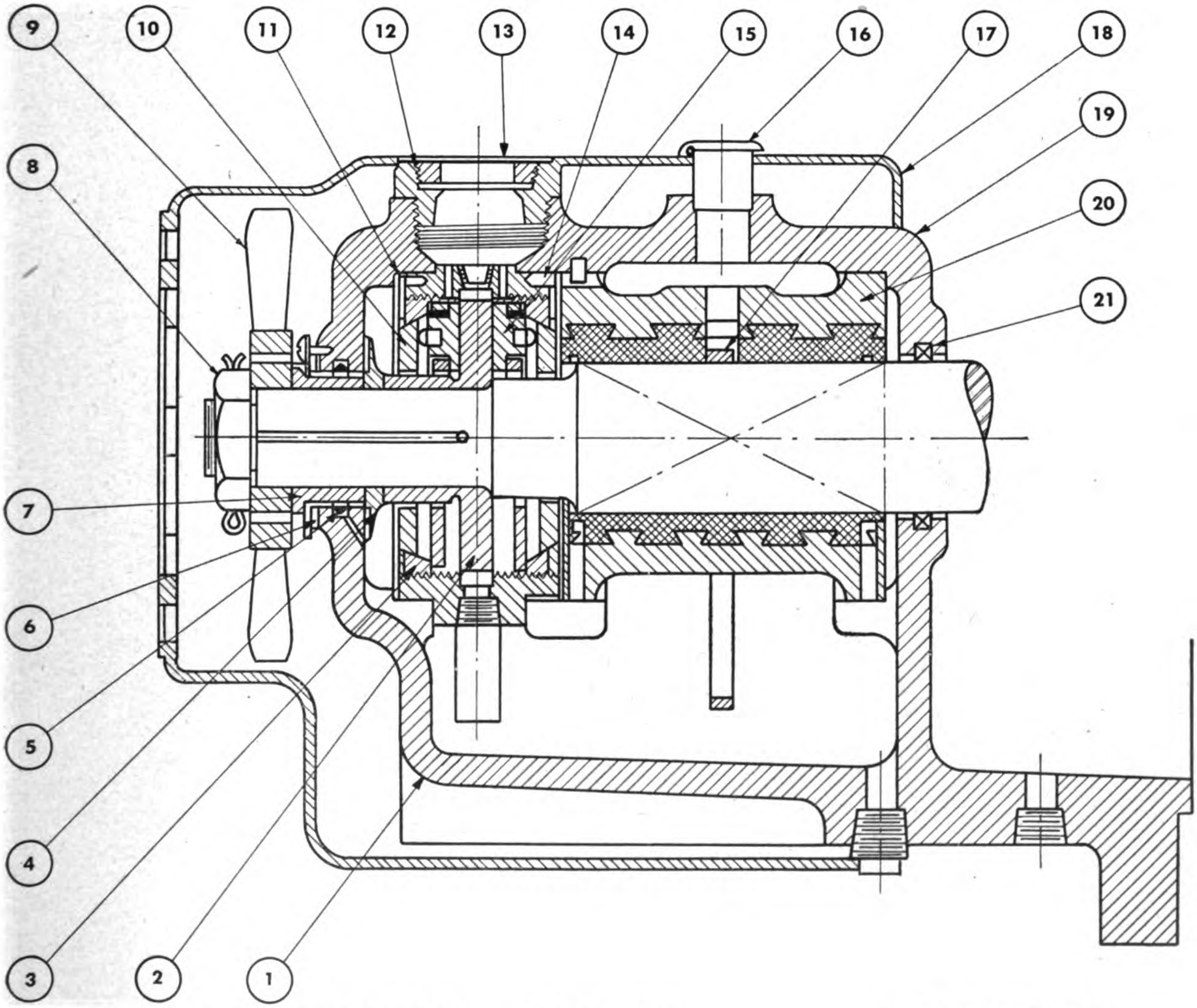
8 (5) *Grease-lubricated bearings.* (*a*) For grease-lubricated bearings on slightly inclined shafts equipped with drain plugs, flush thoroughly with light mineral oil heated to 165° F., or with carbon tetrachloride, which is noninflammable, does not require heating, and dissolves grease more quickly than hot oil. Remove carbon tetrachloride completely from bearing housing; carefully wipe any carbon tetrachloride which has accidentally splashed onto insulated windings. Be careful of toxic fumes.

9 (*b*) For grease-lubricated bearings on vertical or steeply inclined shafts, disassemble and clean where possible. Grease with pressure gun if bearings have relief plugs. Lubricate with machine in operation. Run machine a few minutes with relief plug out, wipe off excess grease, and replace relief plug.

10 (6) *Sleeve bearings.* Sleeve bearings include reservoir-oiled (flooded), wick-oiled, and grease- and oil-lubricated plain bearings without oil reservoir. Be sure that all metal surfaces are separated by a film of oil or grease. Use clean oil and oiling devices. Avoid excessive oiling which may damage rubber mounts and bushings, wiring, insulation, and the like.

(7) *Bearings without reservoirs or wicks.* Grease- and oil-lubricated bearings not equipped with oil reservoirs or wicks are lubricated according to use. Lubricate daily if equipment gets severe use or is operated 50 percent or more of the time. Determine proper lubricant individually for each bearing to meet specific service conditions (see par. 7 and table VI).

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	
			11			(8) *Wick-oiled bearings.* Lubricate wick-oiled bearings, generally found on small motors and bearings with small oil cups, with a few drops of light mineral oil, NS 3050. Check for noisy operation and excessive play. To avoid excessive oiling, determine proper amount by considering bearing size, type of service, and experience.
		3				(9) *Thrust bearings.* Lubricate and inspect thrust bearings by procedure given for ball and roller bearings.



① Lower-half bearing-housing thrust end.
② Thrust sleeve.
③ Adjusting ring.
④ Oil slinger.
⑤ Kingsbury oil-seal ring.
⑥ Bearing and seal.
⑦ Spacer sleeve.
⑧ Retaining nut.
⑨ Cooling fan.
⑩ Thrust-shoe retaining block.
⑪ Lock clip.
⑫ Thrust-shoe retaining ring.
⑬ Sight flow.
⑭ Kingsbury housing.
⑮ Thrust-bearing shoe.
⑯ Oil-hole cover.
⑰ Oil ring.
⑱ Bearing jacket.
⑲ Bearing-cap thrust end.
⑳ Thrust-bearing shell.
㉑ Cork oil retainer.

Figure 11. *Air-cooled Kingsbury bearing.*

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	
		4				(10) *Kingsbury type thrust bearings.* The Kingsbury type thrust bearing is a pivoted-shoe type oil bearing (see figs. 11, 12, and 13). In operation, bearing shoes ((15), fig. 11) and thrust sleeve bearing disk (2) are separated by an oil film. The disk is held perpendicular to the shaft by a long shaft sleeve. Bearing shoes are free to tilt both radially and tangentially so when bearing is in operation bearing faces lie slightly inclined to the disk and oil films between are slightly wedge-shaped. Mean thickness of this oil film is rarely more than 0.002 inch. Clearance between disk and shoes should be from 0.004 inch to 0.008 inch. Too little clearance causes heating and excessive clearance allows pump-rotating element to float which may result in bearing knock.
					*	(*a*) **Disassemble.** The thrust bearing may be removed without disturbing the rotating element. (Key numbers refer to fig. 11.) *1.* Remove split bearing jacket (18) and bearing cap. *2.* Lift out upper half of bearing shell; rotate lower half 180° and lift out.

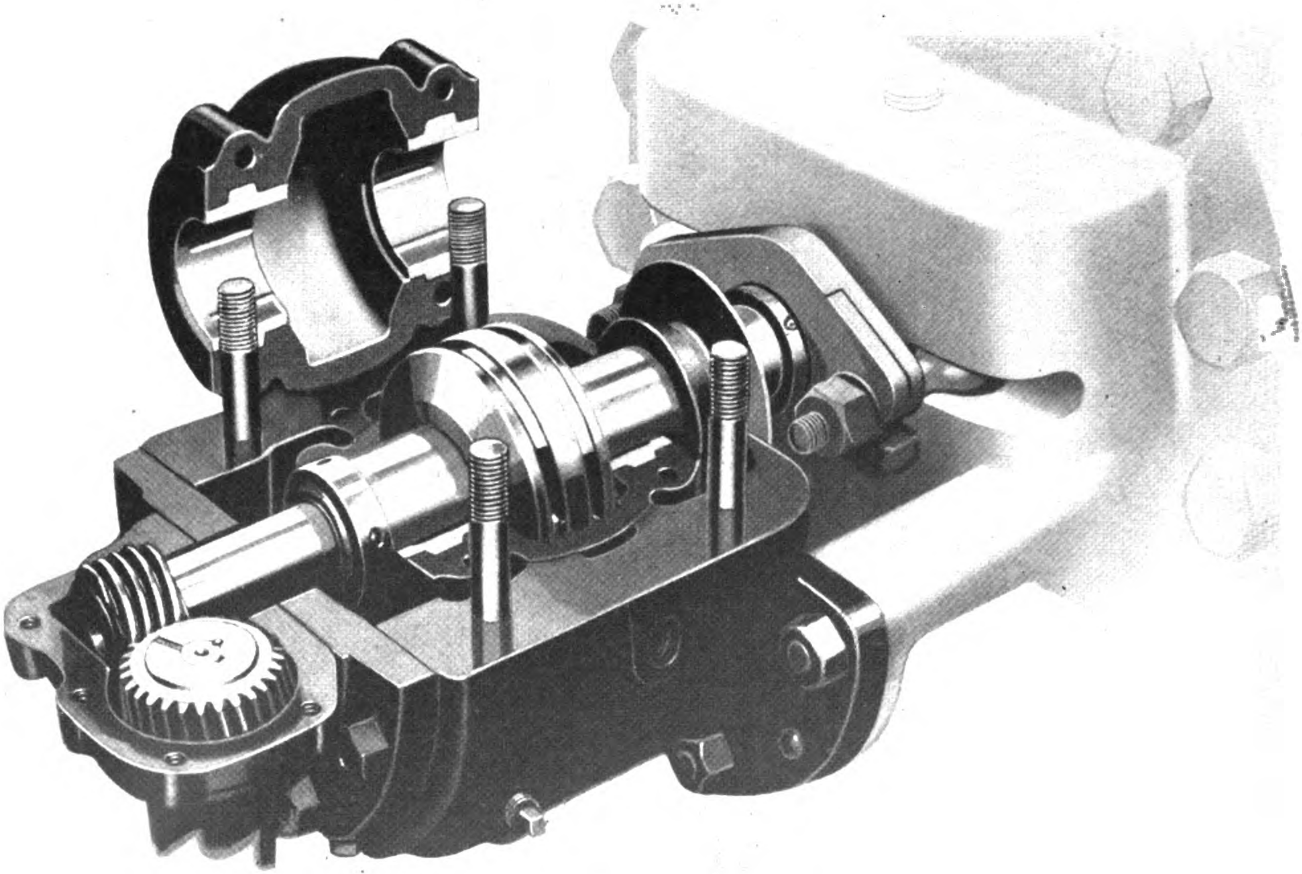


Figure 12. Kingsbury thrust bearing.

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	
						3. Remove bolts holding lower half of bearing housing, rotate above shaft, and remove.
						4. Remove retaining nut (8), fan (9), and complete Kingsbury assembly.
						Note. Scored bearing surfaces cause overheating. Use care in handling thrust disk and bearing shoes. Be sure oil contains no foreign matter.
					19	(*b*) **Change oil.** See *e* below. Refill with new oil, NS 2190 T to required level.
						Caution: If tilting segments or shoes do not have coating of oil, bearing will burn out. Merely filling oil chamber is inadequate, particularly for vertical Kingsbury on deep-well turbine pumps. Coat parts with oil as they are replaced.
				12		(11) *Underwater bearings.* Obtain from manufacturer any data not shown in this manual on clearances or lubrication of underwater bearings. Inspect bearings whenever unit is out of service for inspection. (Basins with

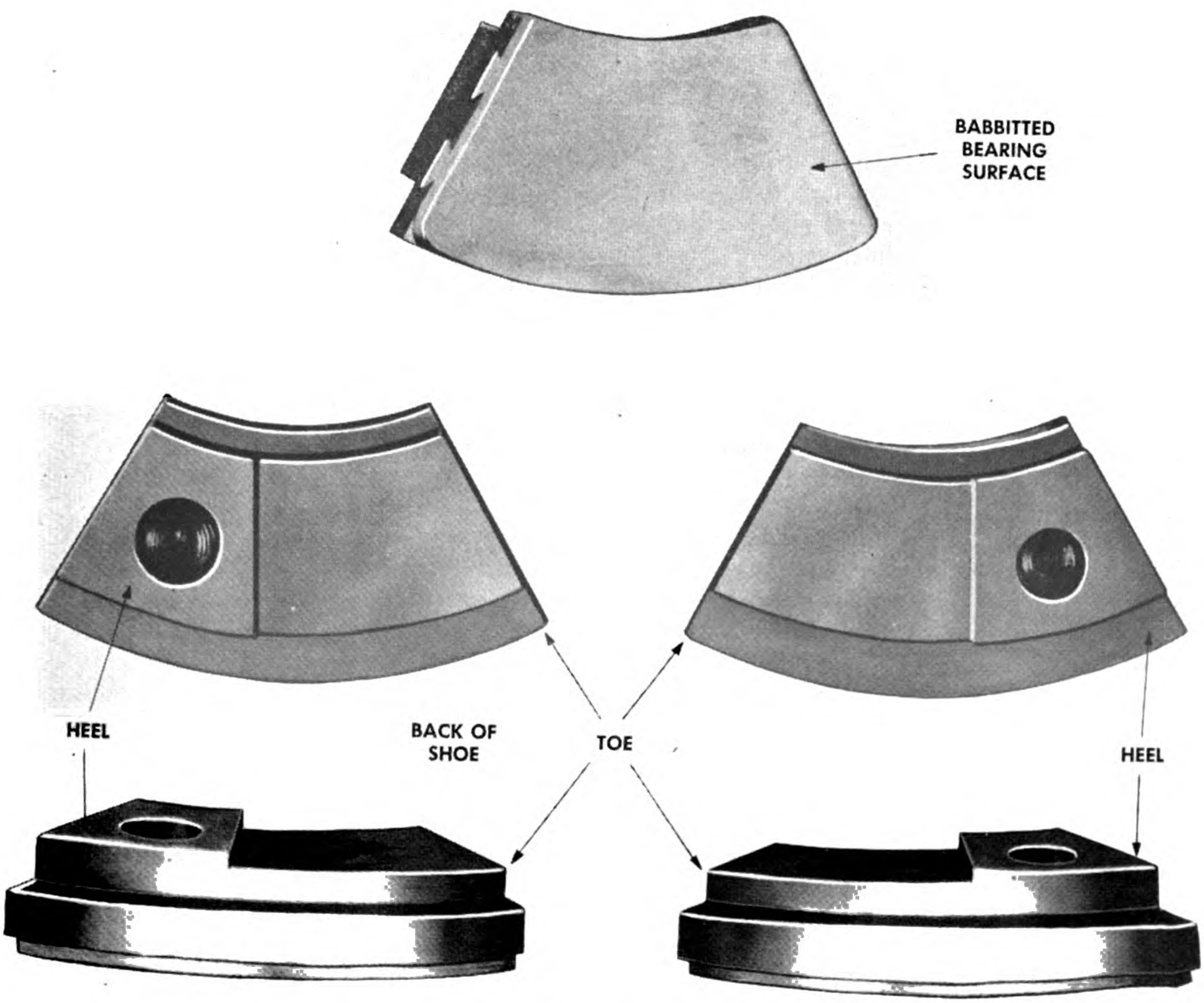


Figure 13. Kingsbury thrust shoes.

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

mechanical equipment are inspected semiannually.) Inspect bearings on well pumps only on pump removal.

20 *d.* **Clean, Check Clearance, and Inspect.** Clean, check clearance, and inspect bearing when machine is given annual overhaul. Disassemble, clean, and wash all parts of bearing with kerosene, including housing and oil lines. Look for defects in bearing surface. Rotate bearing slowly by hand to detect defects. Check for nicks in race. Bearing surface should appear polished on 80 percent of contact area. Clean perfectly all metal-to-metal surfaces, such as between two halves of bearings and top and bottom of boxes. See that paint, metal particles, or dirt do not prevent proper clearance. If gaskets are used in split bearings, be sure they are of proper thickness to hold bearing halves secure and tight without distortion. In case of oil leakage, plastic oilproof sealing compound may be used sparingly between metal surfaces.

(1) *Bearing clearance.* Feeler gauges may be used to measure bearing clearances. Total shaft movement is better measured by dial indicators which show full movement of bearing from contact on one side of shaft to contact on opposite side. Clearances should not exceed 0.002 inch plus 0.001 inch per inch of shaft diameter. If dial-indicator measurement exceeds this value, determine first that play is in bearing, not in some other part of machine, before correcting. If bearing is faulty, replace or repour in the case of babbitt bearings. Repouring and refitting babbitt bearings requires an experienced person. For speeds below 200 rpm, lateral clearance greater than 0.010 inch and end-for-end clearance greater than 0.015 inch are dangerous. Before continuing such bearings in use, check effect on other tolerances in machine.

13 (2) *Kingsbury thrust shoes.* Use feeler gauge to measure clearance in Kingsbury thrust shoes (fig. 13). Move shaft to contact with shoes and insert gauge between shoes and thrust sleeve on opposite side. If feeler gauge cannot be used directly, move shaft to measure end play. If clearance exceeds 0.010 inch, adjust if possible. Replacement of worn shoes rebabbitting may be necessary in some types of these bearings.

14 (3) *End play of Kingsbury thrust bearing.* Follow procedure shown in (1) above.

21 (4) *Underwater bearings.* Disassemble when unit is out of service for inspection. Clean bearings in suitable solvent. Check any lubrication lines. Inspect bearing and shaft for scoring. Measure clearances and compare with manufacturer's tolerances. Reassemble and lubricate. Paint with suitable underwater paint or apply adequate protective coating.

15 *e.* **Change Oil.** If bearing has oil reservoir, drain out old oil. If drainings are dirty, flush bearing with kerosene. Refill to proper level with new NS 2190T, suitable for temperatures less than 160° F. Look for oil leakage and remedy cause. Do not fill oil-level cups to overflow. Enough oil is present when oil rings are carrying oil. Observe machine in operation for unusual bearing noise, vibration, and proper operation oil rings.

5 *f.* **Add Oil.** To add oil, refill to proper level with new NS 2190T, which is suitable for temperatures up to 160° F.

22 *g.* **Clean Water-cooling Systems.** Drain cooling jacket or water-cooled bearings and observe condition of cooling surfaces for scale and corrosion. Flush

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

out system. Inhibited acid, Oakite, or equal may be used for cleaning. When handling acid, wear suitable protective clothing.

24. Couplings

a. General. Unless couplings between the driving and driven elements of a pump or any other piece of equipment are kept in proper alignment, breaking or excessive wear results in either or both the driven machinery and the driver. Burned-out bearings, sprung or broken shaft, excessively worn or ruined gears are some of the damages caused by misalignment. To prevent outages and the expense of installing replacement parts, check the alignment of all equipment *before* damage occurs.

(1) Improper original installation of the equipment may not necessarily be the cause of the trouble. Settling of foundations, heavy floor loadings, warping of bases, excessive bearing wear, and many other factors cause misalignment. A rigid base is not always security against misalignment. The base may have been mounted off level, which would cause it to warp.

(2) Flexible couplings (fig. 14(1)) permit easy assembly of equipment, but they must be aligned as exactly as flanged couplings if maintenance and repair are to be kept to a minimum. Rubber-bushed types cannot function properly if the bolts cannot move in their bushings.

1 *b.* **Check Coupling Alignment.** Excessive bearing and motor temperatures caused by overload, noticeable vibration, or unusual noises may all be warnings of misalignment. Realign when necessary, using a straightedge and thickness gauge or wedge (fig. 14(2)). To insure satisfactory operation, level up to within 0.005 inch as follows:

(1) Remove coupling pins.

(2) Rigidly tighten driven equipment; slightly tighten bolts holding drive.

(3) To correct horizontal and vertical misalignment, shift or shim drive to bring coupling halves into position so no light can be seen under a straightedge laid across them. Place straightedge in four positions, holding a light back of straightedge to help insure accuracy.

(4) Check for angular misalignment with a thickness or feeler gauge inserted at four places to make certain space between coupling halves is equal.

(5) If proper alignment has been secured, coupling pins can be put in place easily using only finger pressure. *Never hammer pins into place.*

(6) If equipment is still out of alignment repeat the procedure.

2 *c.* **Change Oil in Fast Couplings** (fig. 14(3)). Drain out old oil and add gear oil to proper level. Correct quantity is given on instruction card supplied with each coupling.

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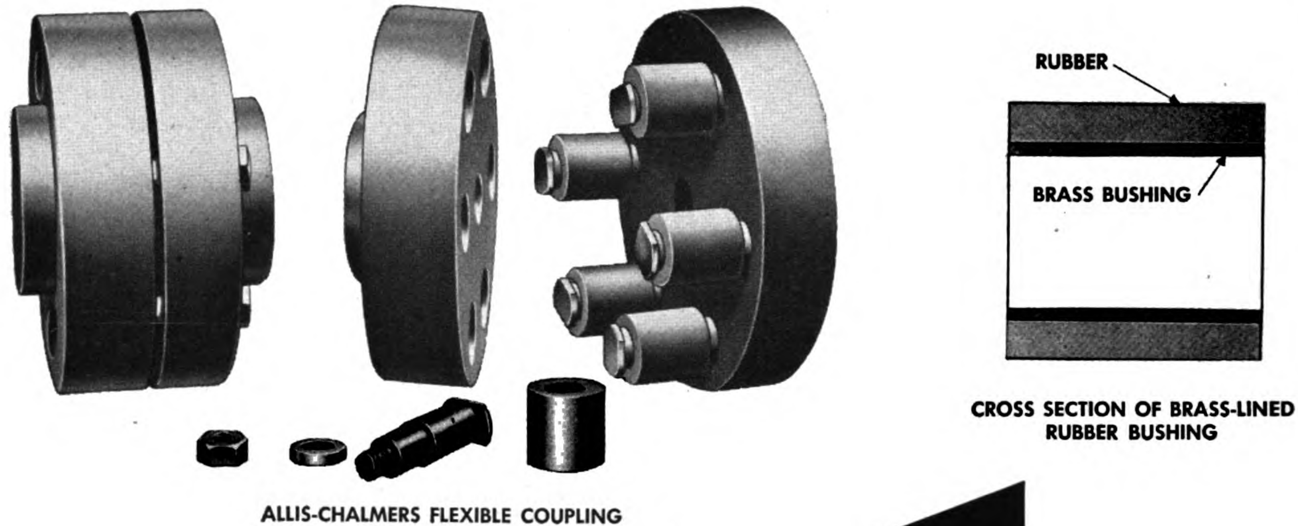

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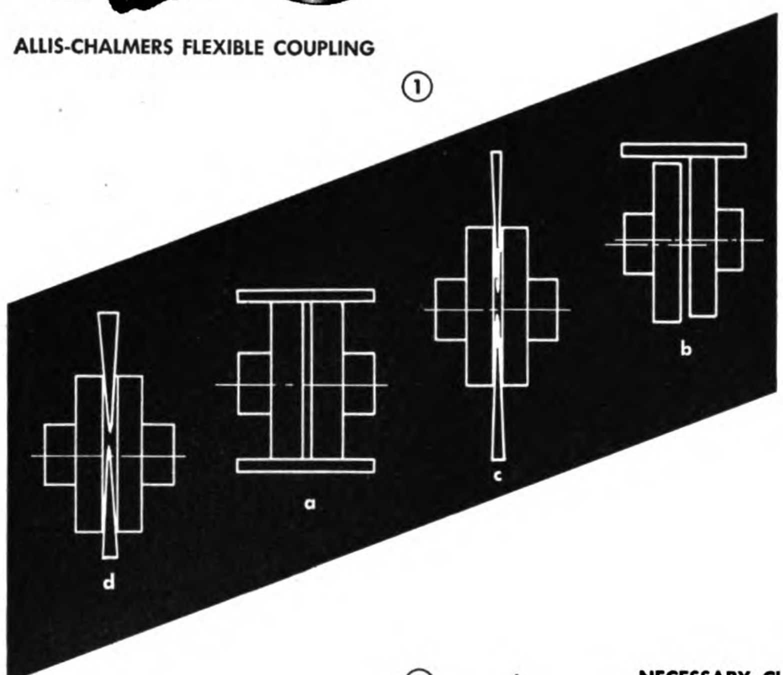

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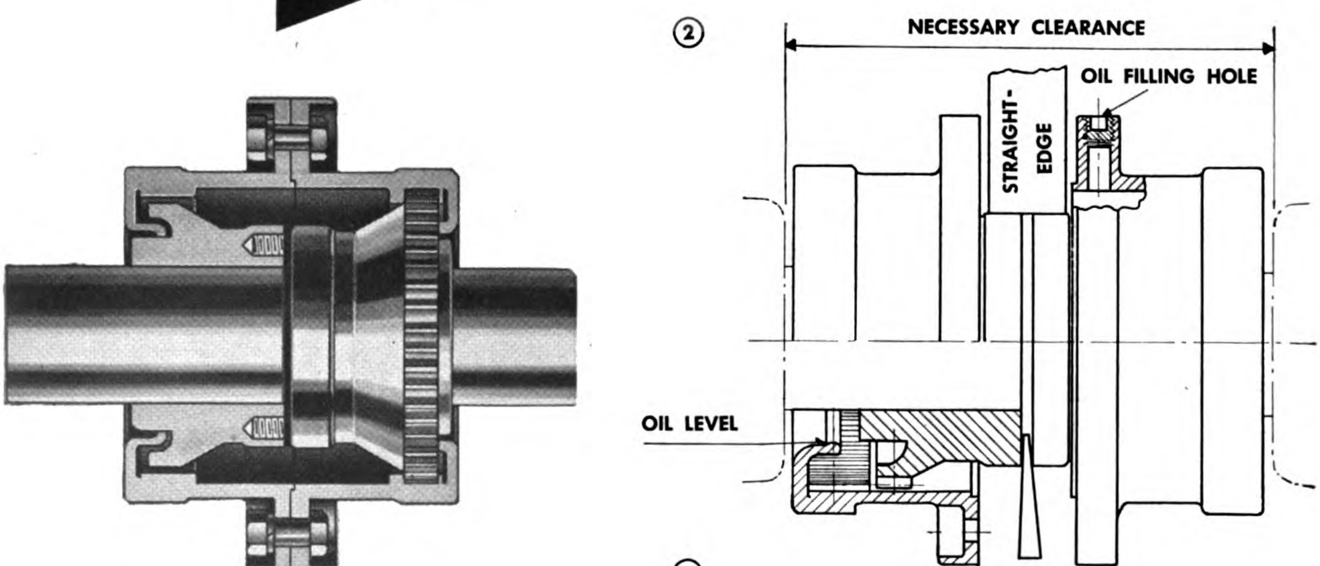

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① Flexible coupling. ② Method of alignment. ③ Fast coupling.

Figure 14. Coupling.

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	
						25. Shear Pins
						Many water treatment units have shear pins, protective devices to prevent damage in case of sudden overloads. To serve their purpose, these devices must be in condition to operate; under unfavorable operating conditions, shearing surfaces of a shear-pin device may freeze together so solidly that an overload fails to break them.
						Manufacturers' drawings for particular installations usually specify shear-pin material and size. If not, obtain the information from the manufacturer, giving him model, serial number, and load conditions of unit. When necessary to determine shear-pin size quickly, select by trial the lowest strength which does not break under unit's usual loads. When proper size is determined, never use a pin of greater strength, a bolt, or a nail. If necked pins are used, be sure necked-down portion is properly positioned with respect to shearing surfaces. When a shear pin breaks, determine and remedy cause of failure before inserting a new pin and starting drive in operation.
		1				*a.* **Grease Shearing Surfaces.** Use WB 2 grease or oil with OE 30.
			2			*b.* **Remove Shear Pin.** Operate motor for a short time to smooth out any corroded spots.
					3	*c.* **Check Spare-pin Inventory.** Make sure an adequate supply is on hand, properly identified and with record of proper pin size, necked diameter, and longitudinal dimensions.

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

SECTION V
WELLS

26. General

a. DEFINITIONS. Static water level is the level or elevation of water in the well before pumping. Pumping level is water level or elevation of ground water in the well while pumping at a definite rate. Draw-down is the difference between static level and pumping level. After pumping starts, the water level falls gradually and draw-down cannot be determined until the pumping level becomes stationary.

b. LEVEL AND DRAW-DOWN GAUGE. The following is a simple accurate method of checking water level (see also fig. 15):

(1) Lower small ¼-inch air-line pipe (telltale) of known length into well. Place tee in the line above ground, fitting a pressure gauge into one connection and an ordinary bicycle (Schraeder) valve with bicycle pump attached into the other. Make all joints airtight.

(2) When well pump is not operating, apply pressure through bicycle pump until gauge needle no longer registers increased pressure. As air is forced into the line, gauge registers pressure required to force water out of submerged portion of pipe. Deduct this pressure converted to feet (pounds pressure x 2.31) from known length of ¼-inch air-line pipe to get static level of water below air gauge.

(3) Start pump and observe gauge until reading no longer changes, pumping in additional air as needed to make up for any leakage. Again deduct this pressure reading converted to feet from the known length of air-line pipe to get pumping level below air gauge. Difference between static level and pumping level equals draw-down.

Example: Assume a length (L) of 150 feet. Pressure-gauge reading before starting pump $(P_1)=25$ pounds per square inch. Then pressure converted to feet $(A)=25 \times 2.31=57.7$ feet. Static water level $(B)=L-A=150-57.7=92.3$ feet. Pressure-gauge reading when pumping $(P_2)=18$ pounds per square inch and pumping pressure converted to feet $(C)=18 \times 2.31=41.6$ feet. Pumping level $(D)=L-C=150-41.6$ feet $=108.4$ feet.

(4) Draw-down is determined by any of the following methods:

(*a*) $D-B=108.4-92.3=16.1$ feet.

(*b*) $A-C=57.7-41.6=16.1$ feet.

(*c*) $P_1-P_2=25-18=7$ pounds per square inch; $7 \times 2.31=16.1$ feet.

1 *c.* **Measure Water Levels and Draw-down.** Measure static level, pumping level, and draw-down on each well. If daily measurements cannot be made because of the large number of scattered wells, measure at least twice a month.

2 *d.* **Record Water-level and Draw-down Determinations.** Maintain careful records of static level and draw-down correlated with capacity or pumping rate. This helps to anticipate difficulties in advance and provides data for proper maintenance measures. The following examples prove the value of properly maintained records:

(1) A falling static level may indicate gradual lowering of water table for causes beyond control of the post or reveal interference by other post wells.

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY

(2) An increased draw-down may show receding ground-water level, interference of other wells, leaky casing or delivery pipes, clogging, scaling, or corroding of well screen, gravel area and adjacent stratum becoming packed with sand or silt, or a cave in of water-bearing stratum.

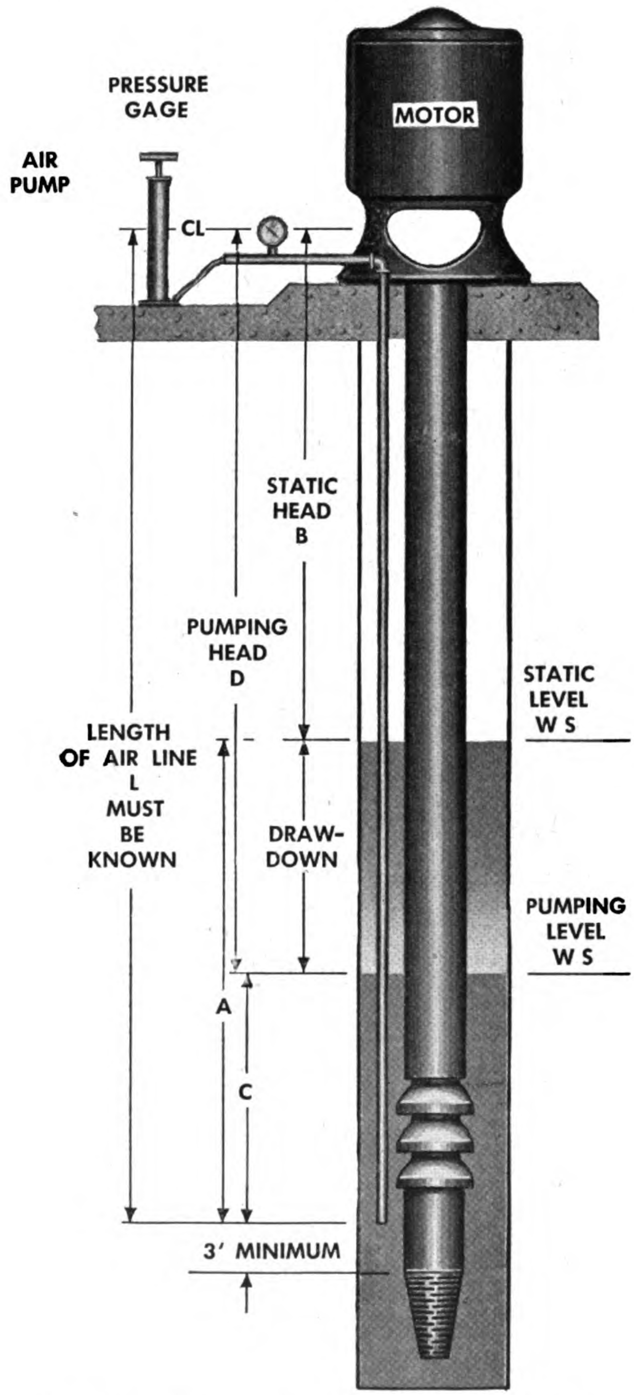


Figure 15. Using air line to find depth of water level.

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY

(3) An increased draw-down when static level is unchanged is caused by increased resistance to water inflow and definitely indicates screen clogging, scaling, corroding, or sand and silt in gravel-packed area around screen or adjacent stratum.

[Weekly: 7] *e.* **Check for Safe Pumping Yield.** From daily and weekly operating records, determine whether quantity of water pumped is exceeding safe yield of the well. To prolong the life of a well, especially a gravel-wall well (fig. 16), and greatly decrease maintenance at proper yield, set capacity at 50 percent of maximum draw-down.

Example: A 110-foot well which yields 500 gallons per minute has a static water level of 20 feet and a pumping level of 100 feet, or an 80-foot draw-down. Satisfactory pumping level is 60 feet or 50 percent of maximum draw-down and well capacity is accepted and maintained for that condition.

[Annually: *] *f.* **Clean Well Screens.** When operating data on yield or draw-down show that well-cleaning is necessary, use one of the following methods:

(1) *Inhibited muriatic acid.* Clean incrusted brass, bronze, or stainless-steel screens with inhibited muriatic (hydrochloric) acid. Acid ruins galvanized screens. Estimate severity of incrustation by comparing present static level, pumping level, and recovery time with data recorded when well was first placed in operation. Do not permit post operating personnel to use the acid process; employ a qualified well man. Make sure protective clothing is worn when acid is being handled.

(2) *Dry ice.* Cleaning with dry ice is simple and safe. However it is experimental and may not give desired results. To use this method, drop dry ice in well casing and seal top of well. The gas expansion creates a violent surging which produces back pressure, backwashing the screen.

(3) *Blasting.* *Never* use blasting caps or small charges of dynamite to clear clogged or incrusted screens. This practice, known as shaking or bumping, is extremely dangerous.

[Annually: *] *g.* **Backwash.** (1) Post personnel can backwash a well without pulling pump out of well and without expert help. Backwash by starting and stopping pump at short intervals. When pump is stopped, water surges through pump bowls and up the well, partially washing the screen. Repeat process of starting and stopping pump until discharge is completely clear.

(2) If surging does not give desired results, backwash with large volumes of water. If bypass pump connections or wash-water lines have not been made for this operation, remove flap in check valve in discharge line to obtain full head of water with tank pressure. Open discharge line valve and allow full head of water to rush through pump column and pump and into well. If screen is badly clogged or well badly sanded or silted, well will quickly fill and flow from the ventholes in pump head.

Caution: Before starting wash water, be sure pump and motor turn freely; otherwise downrush of water rotates pump in wrong direction and unscrews pump shafting. Allow backflow to continue for several minutes; then close wash-water valve, open pump-out valve, and start pump. Continue pumping until well has cleared and repeat operation. Measure water level and capacity to check results. For gravel-wall wells, check gravel level if possible and fill

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY

gravel chamber with sterilized gravel. Washing may bring well back nearly to original production.

(3) The best way to clean a sand well is by a combination of backwashing with water and back-blowing with compressed air after pump has been pulled from the well (fig. 17). This method washes screen, breaks down sand and silt impacts, and removes slime and coating. Compressed air gives a better surging and washing effect than straight backwashing with water and has the added

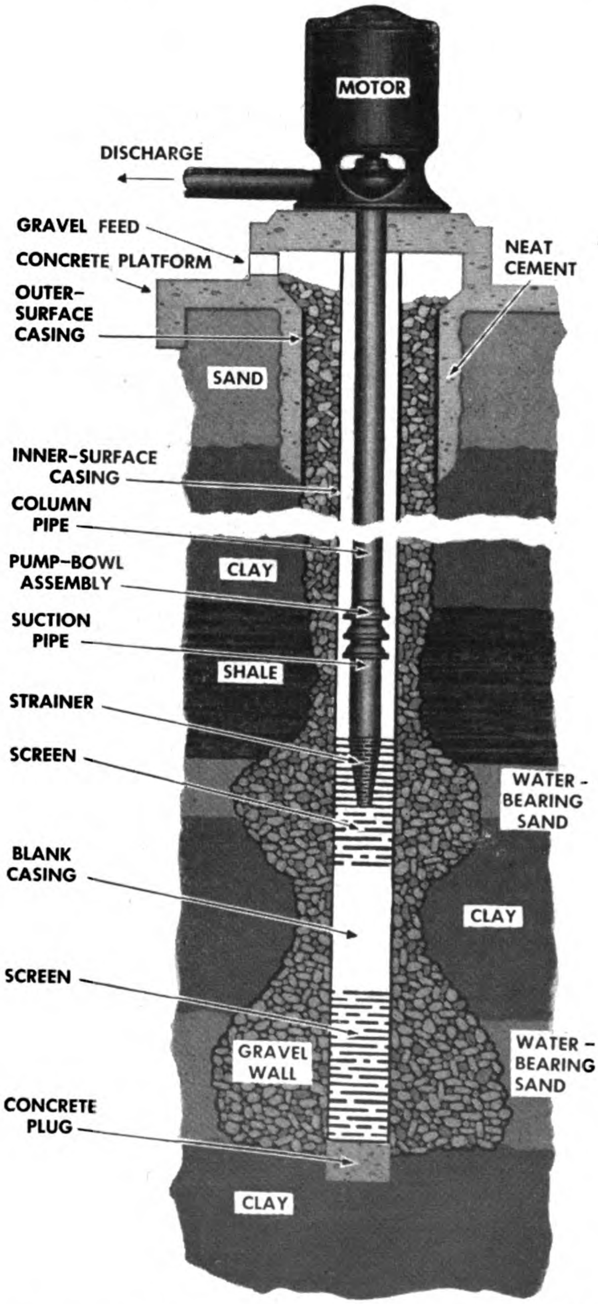


Figure 16 Gravel-wall well, with two sands developed.

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY

advantage of enabling air-lift pumping of large quantities of sand without damaging the well pump. **Use only experienced well men for this work.** Procedure is as follows:

(*a*) Remove well pump. Lower a 4-inch pipe (eduction or flow line) into well until lower end has at least twice the elevation of the pumping level. Place

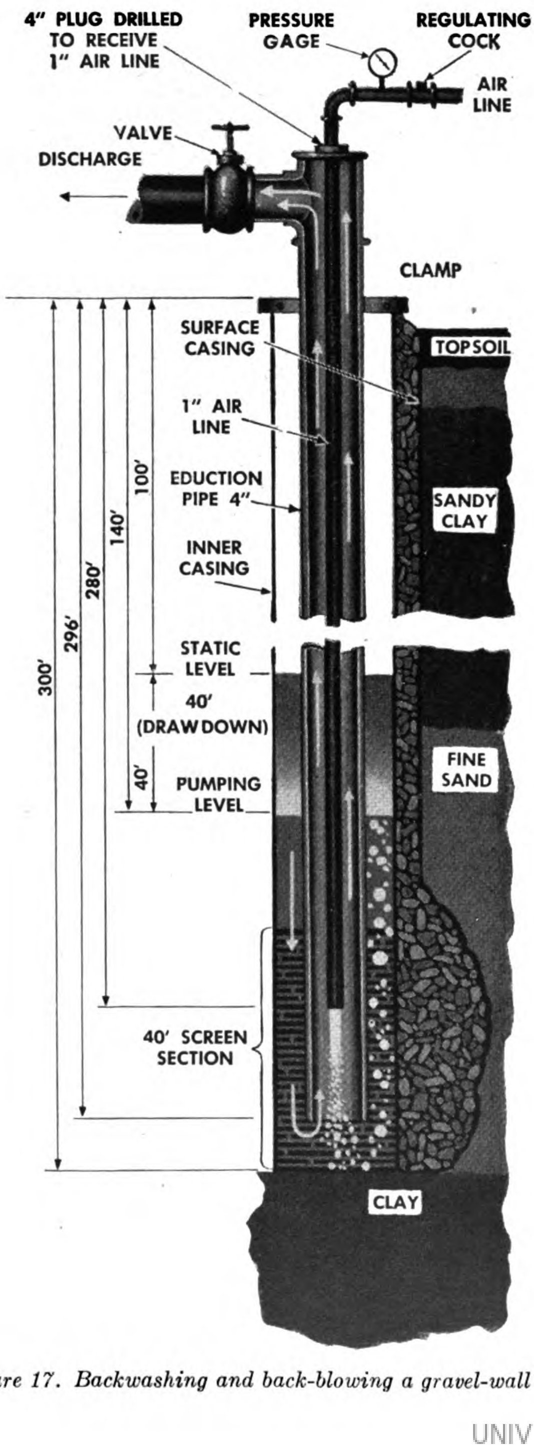


Figure 17. Backwashing and back-blowing a gravel-wall well.

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY

4-inch T on top of pipe, with T-outlet center line horizontal. Screw a valved length of 4-inch pipe into T-outlet for water discharge line.

(*b*) Thread upper end of a 1-inch pipe (air line) through center of a properly drilled and tapped 4-inch pipe plug. Insert the 1-inch pipe into the 4-inch pipe, so bottom of air line is approximately 24 inches above bottom of 4-inch pipe. Screw pipe plug with air line into 4-inch T on top of eduction pipe. Connect air line with nonrigid connections to portable compressor having at least 110 cfm capacity.

(*c*) Build up pressure until water flows through eduction pipe. Allow to flow until pressure becomes stationary, indicating pumping level. Continue pumping until water is clear, then release air and allow well to recover. Close 4-inch valve in discharge line and again apply air to well until the static head is reached. Air then escapes from bottom of 4-inch pipe and well surges and pumps in inner well casing and through screen, causing sand and gravel movement. After a few minutes, open 4-inch valve in discharge line and allow washed-in sand and silt to be pumped out. When water becomes clear, repeat operation, each time lengthening back-blowing time. To obtain quicker and more effective results, pump water into well through casing at the same time air is pumped into well.

(*d*) Check results after each surging and cleaning operation. An increased pumping pressure indicates rising water level showing increased inflow to well and decreased draw-down.

(*e*) Do not back-blow too heavily when starting operation. Keep gravel chamber full at all times to prevent sand heaving and cavities which allow top silt or clay to cave and deposit around screen. Excess air is desirable for this cleaning operation; with 50 percent submergence, 0.5 cubic feet of air per minute per gallon of water pumped is enough for lifts up to 100 feet, 0.7 cubic feet per minute per gallon up to 200 feet, 1 cubic foot per minute per gallon up to 400 feet, and 1.5 cubic feet per minute per gallon up to 500 feet. After all pipe is removed and before reinstalling pump, sterilize well, check static water level, and place enough gravel in chamber to replace sand removed.

18 *h.* **Inspect Sanitary Conditions.** (1) **Check surface drainage.** Make sure earth surface slopes divert surface water from well or pump house and that grades prevent accumulation and retention of surface water within 50 feet of the well. Ditch away any accumulated or retained water.

19 (2) **Check livestock.** If livestock roam on the reservation, erect a fence around the well site, at least 50 feet from the site. See that areas accessible to livestock drain away from the water source.

20 (3) **Check platform.** See that concrete slab or platform around well or well house is watertight and that no water can work under floor and into well.

21 (4) **Check top of well casing.** See that top of well casing and well head are completely sealed at all times.

12 (5) **Check well vents.** Well vents retain atmospheric pressure conditions in the well and prevent entrance of contamination. See that air vent is not clogged, is properly screened, and ends in an elbow or equivalent which points down and is at least 12 inches above top of well casing and 18 inches above pump-house floor.

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	
		13				(6) **Check priming and lubricating water.** Make sure water used for bearing lubrication and pump priming is safe and from an approved source.
				22		(7) **Check well pits.** See that well heads, well casing, pumps, pumping machinery, exposed suction pipes, or valve boxes connected with a suction pipe are not located in any pit, room, or space extending below ground surface. Keep pit dry, clean, and well sealed.
				23		(8) **Check water-sample tap.** See that water-sample tap is installed in discharge line near the pump, facing downward.
				24		(9) **Check cooling water.** Make sure water for cooling parts of engines, air compressors, pumps, or other equipment is not returned to any part of the water system.
		14				(10) **Check air-lift system.** Check that air from compressor discharges into an air-storage tank designed to extract oil or oil mist picked up by air during passage through compressor. An air-compressor cylinder requires very little oil. See that compressor intake has air filters. Clean air filters monthly. Where air filters are not installed, make sure intake is properly protected to prevent entrance of birds, insects, rain, snow, or other contaminating material and to minimize entrance of dust.
		15				**Blow down air-storage tank.** Drain off collected oil and moisture.
			17			(11) **Check observation wells.** See that all observation wells located near pumping well are properly capped and watertight.
						27. Straight-bored Wells
						a. GENERAL. Straight-bored wells (figs. 18 and 19) have a straight hole, usually drilled with cable tools. Water is secured from a broken formation or from rock, usually sandstone. Water-bearing strata need not be cased in all instances. These wells are easily maintained and long-lived. Failure may be caused by collapse of casing, caving where well is not completely cased, constant lowering of water level by overpumping, corrosion of screen or slots in casing, clogging of screen openings by silt or clay washing down around screen from top formation, and depletion of water stored in the aquifer.
	8					*b.* **Check Water Levels and Draw-down.** Check water levels at least weekly in both producing and observation wells to determine water-level trend (par. 26). Record levels on permanent records.

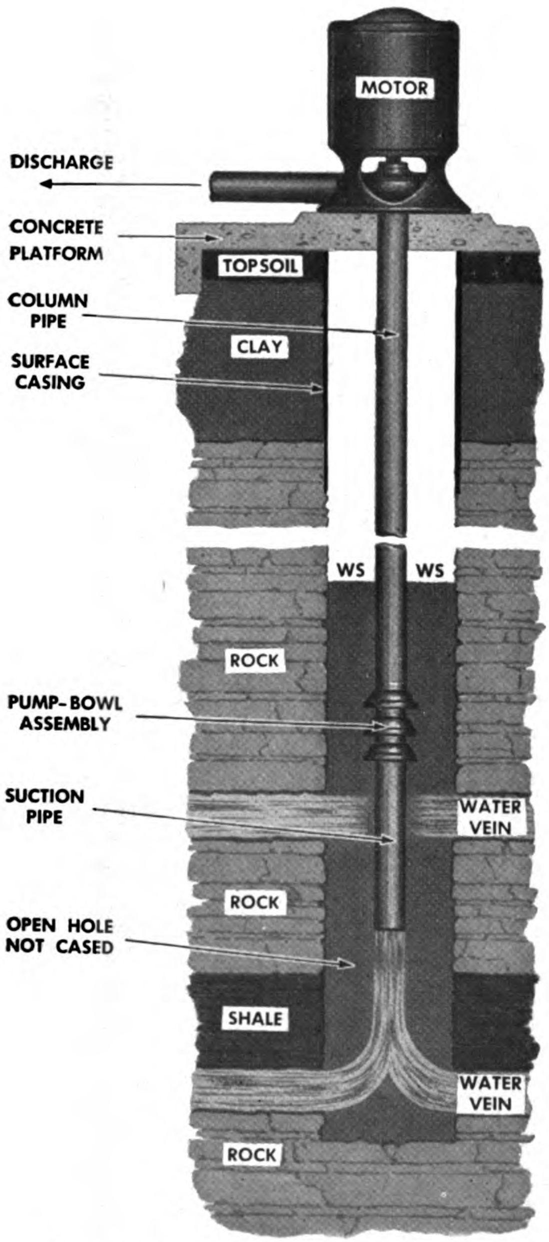


Figure 18. Straight-bored well, partially cased.

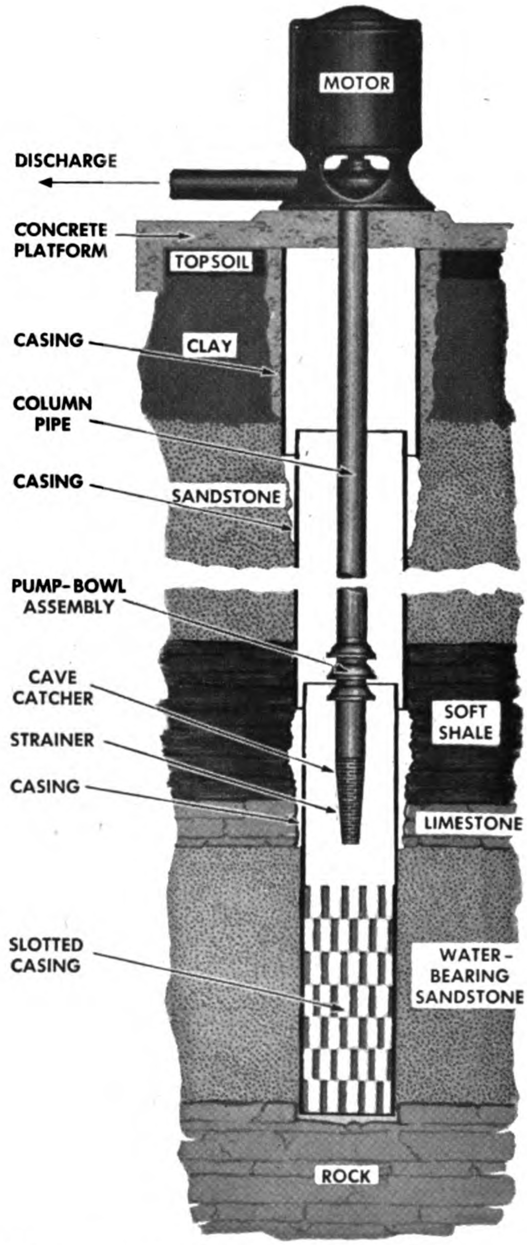


Figure 19. Straight-bored well, completely cased. Note telescoping casing.

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY

28. Large Gravel-wall Wells

a. GENERAL. Large gravel-wall wells are usually constructed in loose sand and gravel deposits. A steel caisson, usually 30 to 40 inches in diameter, extends from ground surface through the water-bearing stratum. The portion of caisson in the water-bearing stratum is a screen section surrounded by a wall of properly placed and graded clean, washed gravel (fig. 20). This well requires considerable maintenance because of sand or silt packing around screen

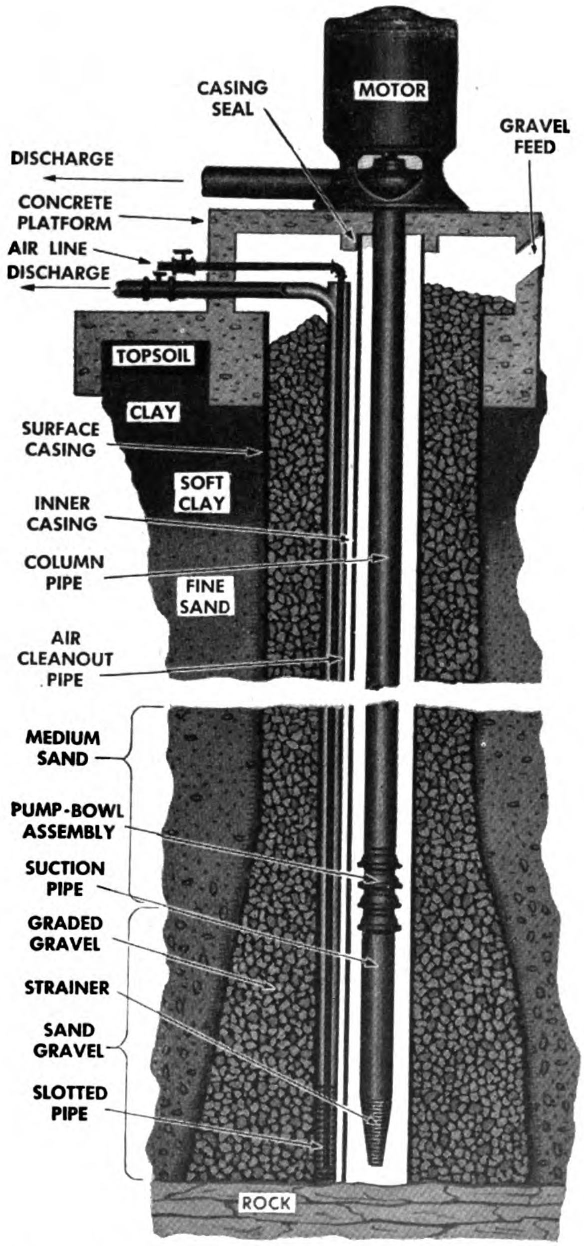


Figure 20. Large diameter gravel-wall well constructed by caisson method.

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	
						in gravel space, screen section becoming clogged or corroded, lowering of water table because of lack of rain on drainage area, or wear on pump.
3						*b.* **Check Levels and Draw-down.** Determine static water level, pumping level, and rate of pumping (see par. 26), and record in permanent record book.
	9					*c.* **Check Gravel.** Check position of gravel around screen and keep gravel level above top of screen at all times. When well is constructed with gravel chamber to ground surface, keep chamber full at all times to prevent top sands and clays from working into gravel and around screen.

29. Large Dug Wells

Dug wells are fairly large holes dug into the water-bearing stratum (fig. 21). Excavation is generally done by hand. Some dug well for public water supplies are 70 feet or more in diameter. A large diameter serves as a storage reservoir and increases the yield. The lining above the water-bearing stratum, called well curbing or casing, is usually made of brick, concrete, or steel pipe. Either the lining through the water-bearing stratum or the entire well bottom must be porous. Carrying the porous lining to the ground surface is dangerous because of potential surface contamination.

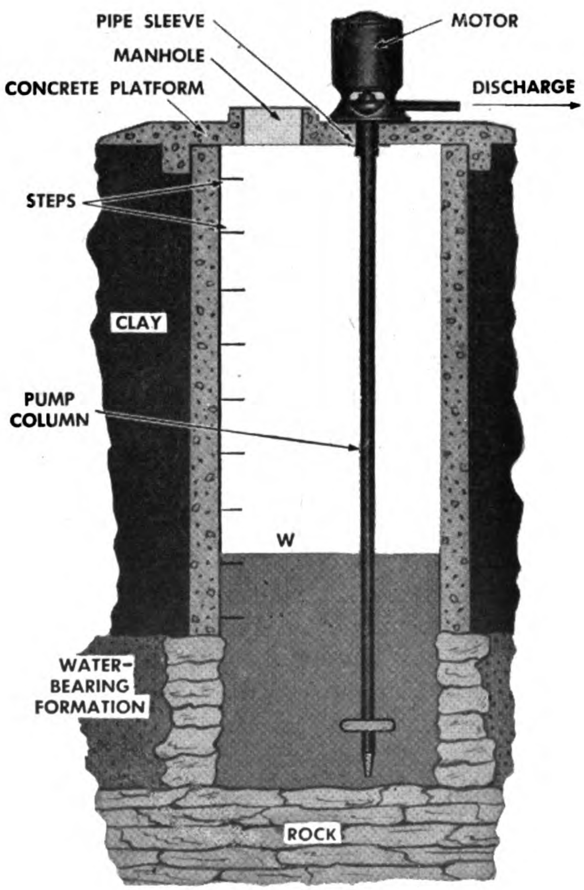


Figure 21. Large dug well.

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

* *a.* **General Maintenance.** Large dug wells in rock or broken formations require minimum maintenance; those in loose sand deposits in the alluvium of river valleys, old sand-carrying stream channels, or terraced sand areas soon become sand-packed and require excessive maintenance. Need for maintenance increases when well is pumped too heavily or when the water level is very low for long periods.

(1) *Pumping rates.* Pumping rate for this type should be very slow and draw-down should not exceed half the total water depth when not pumping.

(2) *Sealing of water flow.* Because silt and sand packing can cause the well to seal itself completely, the well must be kept clean. When the well has brick or másonry curb, removing several bricks at intervals in lower part of water-bearing sand area may cause enough movement of water and sand to break the seal and open the sand stratum. Take care not to remove so much sand that caving the well results.

(3) *Increasing yield.* To increase the yield of a dug well which is low because of clogging, sand packing, or falling water table, drilled or driven wells are sometimes constructed in the dug well bottom. Sand points extending horizontally from bottom circumference of the dug well may be washed in hydraulically to increase yield. These operations require competent well men.

4 *b.* **Measure Water Levels and Draw-down.** Measure static and pumping levels and draw-down. Check pumping capacities. Record water levels and pumping capacities.

10 *c.* **Check Deposits.** Check deposits of sand and silt in bottom of well and clean before more than 1 foot accumulates.

11 *d.* **Check Drainage.** Check drainage to well after each rain to see that surface water is diverted.

30. Rotary Wells (Straight and Underreamed)

Straight rotary wells (fig. 22) are drilled by hydraulic rotary methods which hold sands and loose formations in place by heavy drilling muds. Because mud is also forced into the water-bearing sand, it must be properly removed during well development. Failure to remove mud makes heavy backwashing or back-blowing necessary to maintain water production. Production loss requiring maintenance is also caused by sand and silt packing around screen from overpumping or low water level; screen section becoming sand packed, mud clogged, scaled, or corroded by chemicals in water or by improper screen slot openings or screen material; lowering of water table in area; faulty construction or development; wear on pumps by improper setting, failure to maintain proper alignment or improper lubrication; or shifting of screen and casing because of sand and gravel movements.

a. Underreaming. For gravel-wall rotary wells, drill a straight rotary hole and underream water-bearing sand to a diameter of 18 to 36 inches. Fill space between screen section and underreamed outside wall with clean, properly graded gravel (fig. 23). Use space between an inner and outer casing to add gravel which replaces sand removed from well during pumping operation.

5 *b.* **Measure Water Levels and Draw-down.** Check water levels and rate of flow daily. Record these readings on permanent records.

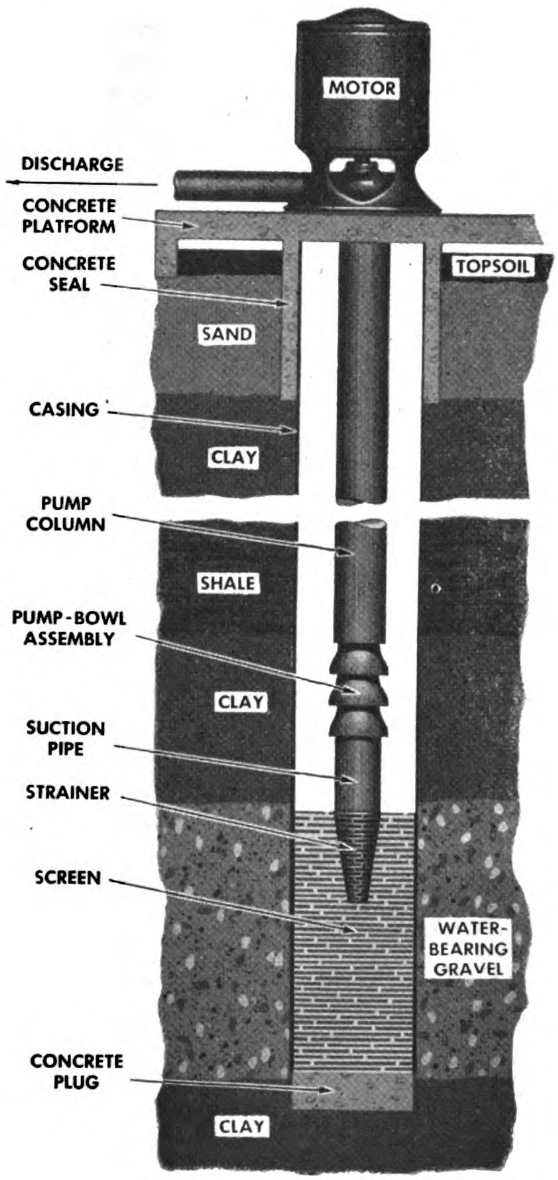


Figure 22. Straight rotary well.

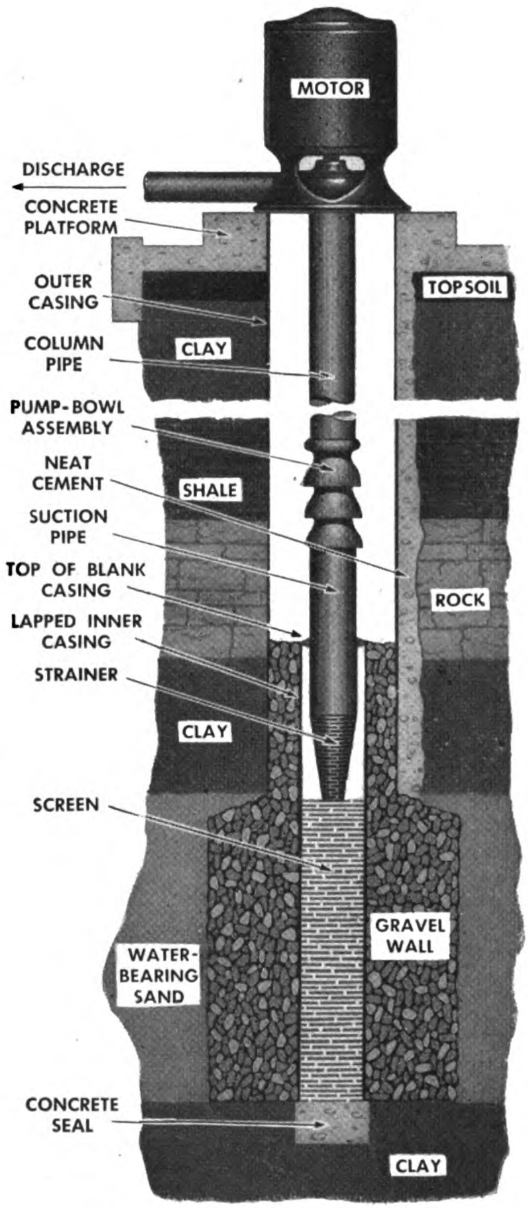
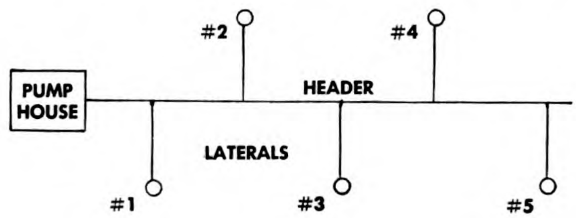


Figure 23. Underreamed rotary well.

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY

31. Sand Point

Sand points are either driven in or washed in by hydraulic pressure (fig. 24). When a well point is driven in, gauze or wrapping on the point may be destroyed or sealed off, necessitating excessive maintenance in a short time. When a point is washed in by jetting with hydraulic pressure, it is clean and will remain open for a longer period of time. When points are clogged by sanding, silting,



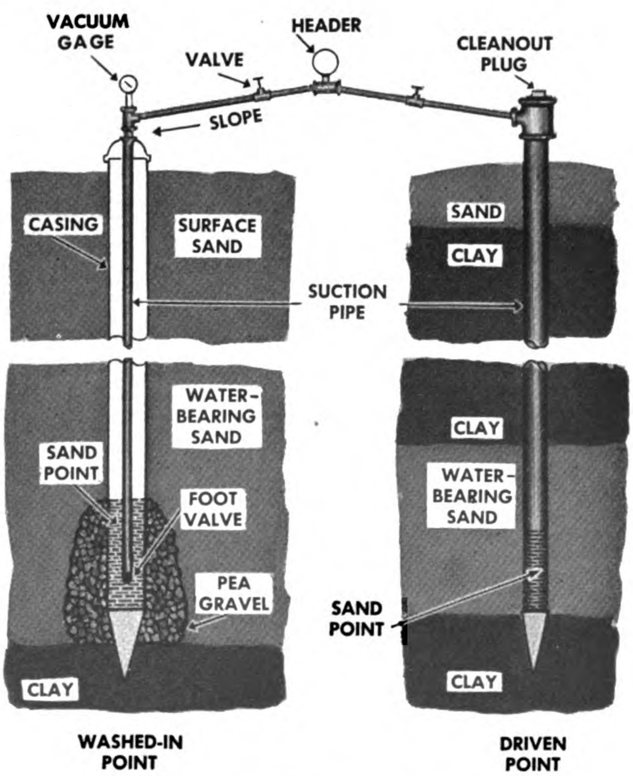


Figure 24. Well-point battery.

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	
						or corrosion, backwash by pumping water back through point until pressure indicates the point is open. ***Caution:*** Do not use pressures over 150 pounds per square inch because screen wrapping will be damaged. If this pressure does not open point screen, pull point and clean with water and brush; if badly corroded, replace it.
6						*a.* **Measure Water Levels and Draw-down.** Check and record water levels daily if possible.
		16				*b.* **Swab Point.** If there is a tee connection at the surface on the pipe to the well point, insert a brush through the tee and swab the point from the surface. This prolongs its life and reduces the pulling interval.

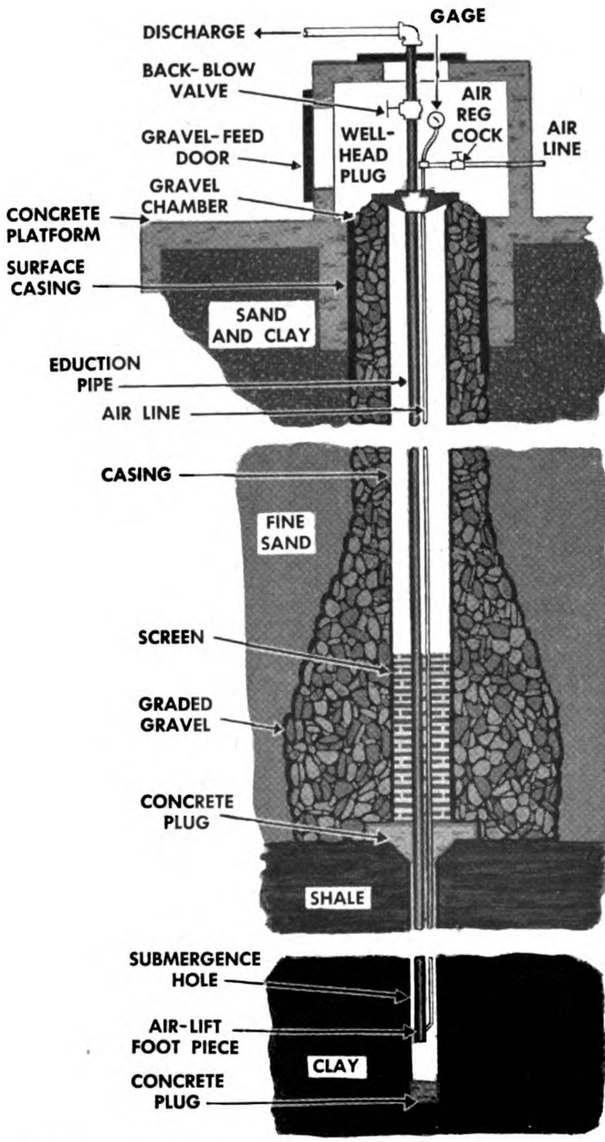


Figure 25. Air-made well with air-lift pumping equipment.

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DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

SECTION VI
SPRINGS

32. Maintenance

3 *a.* **Check Sanitation.** Protect springs with concrete curbing or house built to keep out surface debris, flooding, and animal or accidental pollution, and to prevent objectionable odors and tastes. See that spring basin casings or curbings extend a safe distance below ground surface. Water should enter the inclosing structure at points 10 feet below ground surface. Where this 10-foot distance cannot be obtained without sealing, cutting off, or diverting the underground source, protect springs by an earth fill over the area within a 50-foot radius of the spring to provide recommended depth over points of flow.

2 *b.* **Inspect Overflow.** Check to see that overflow pipe is open or waste discharge orifices are above surface drainage, and that contamination cannot enter basin through these pipes or orifices (fig. 26).

1 *c.* **Check Manhole.** Make sure manhole covers are properly placed.

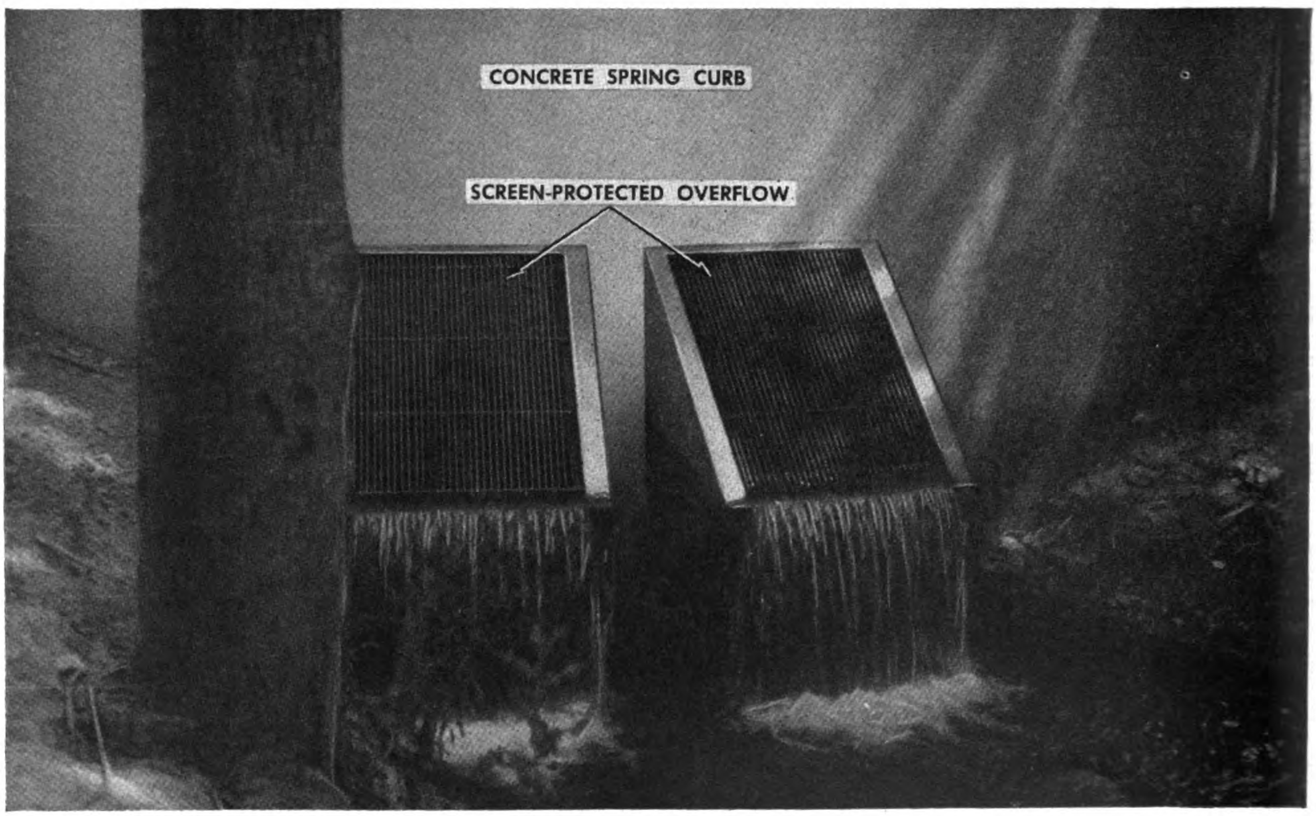

Figure 26. Spring protected from contamination by concrete curb and screening on overflow.

SECTION VII
INFILTRATION GALLERIES

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	
						33. Maintenance
1						*a.* **Measure Static Level and Draw-down.** To insure good operation, measure and keep careful records of static level and draw-down. Measure static level and draw-down in infiltration reservoir or at pump suction.
	2					*b.* **Police and Inspect Catchment Area.** Keep catchment area free from accidental or wilful contamination by fencing it and policing regularly. Do not permit area to be used for agricultural, industrial, or residential purposes.

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY

SECTION VIII
DAMS AND IMPOUNDING RESERVOIRS

34. General

If Army posts obtain water from streams having variable flows, impounding reservoirs are necessary to store water needed during low-flow periods. Natural lakes used as a supply source are considered as impounding reservoirs. Impounding reservoirs are also desirable in swiftly moving streams to provide still water at the intake. This type of reservoir functions to a certain extent as a sedimentation basin, relieving the load on filtration plants to a marked degree.

1 ● *a.* **Inspect Spillways.** Make sure spillways are free from trash and debris because blocking may cause overtopping and possible failure of dam. Earth-fill dams invariably fail if they are overtopped. A log boom stretched across the reservoir about 30 feet behind the spillway helps keep it clear (fig. 27). Use flashboards with great caution. Design and install them so that they fall or wash away when water flows over them.

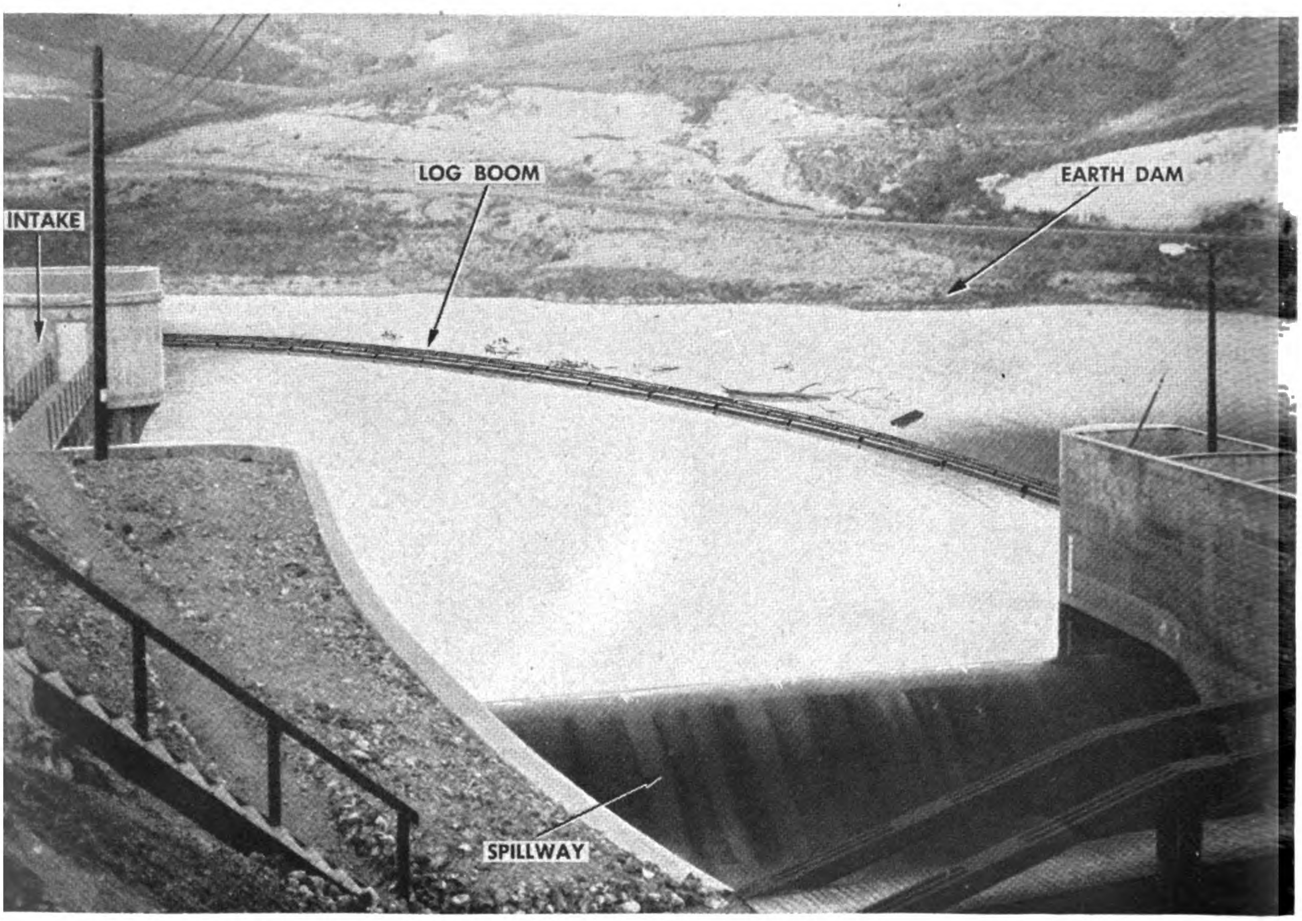

Figure 27. Impounding reservoir. (Note debris caught by log boom, keeping spillway clear.)

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	
		6				*b.* **Inspect and Lubricate Gates.** Inspect and lubricate gates and similar apparatus as required.
						35. Concrete and Masonry Dams
		7				*a.* **Inspect Concrete and Masonry Dams.** Check for leakage. Stop leakage or extensive seepage by plastering upstream face of dam with rich cement mortar. Seal visible cracks with portland cement grout forced into cracks under pressure. Do not attempt to seal cracks on downstream face of dam until upstream face has been properly sealed.
2						*b.* **Protect Dam From Ice Thrust.** When necessary in cold weather, break ice a few feet above crest to protect dam against ice thrust.
						36. Earth- and Rock-fill Dams
						Proper earth dike protection includes making it difficult for water to enter the dike as well as providing means for water that does enter to travel easily to the downstream face at or below the toe of the dam without building up hydraulic pressure within the fill.
	4					*a.* **Inspect Earth-fill Dam.** Keep embankments neat in appearance with slopes well sodded or graveled. Keep riprapping or paving on upstream face even and in good condition.
		8				*b.* **Inspect for Earth-dam Leakage.** Inspect for leakage and extensive seepage. If seepage water flows perfectly clear, no material is being carried away and there is no immediate danger of the leak enlarging. If seepage is continuously muddy, draw off water at once and repair dam by excavating to a moderate depth at upper end of leak and sealing with puddled clay rammed into place. If leak is serious enough, cut down from top and fill with good material, well bonded into original structure and compacted as for a new embankment. Slope of downstream face of dam should be less than slope of hydraulic gradient of the zone of saturation so upper face of saturation zone never intersects the surface. Widespread seepage at downstream toe of dam indicates too steep a slope on downstream face of dam. This condition eventually results in dam failure. When detected, strip off sodding or gravel surface of upstream face and place additional layers of earth on downstream face as for a new embankment.
						37. Impounding Reservoirs
			10			*a.* **Inspect Watershed.** Keep watershed as clear as possible.
	5					*b.* **Inspect for Algae and Aquatic Weeds.** Inspect impounding supply for algae and objectionable weed growths and take necessary remedial measures. During winter months, inspect less frequently.
						38. Intakes
3						*a.* **Measure Draw-down.** Measure draw-down at a known rate of flow and check to see that it is reasonable. Record results. Clean screens and racks if necessary (fig. 28).
		9				*b.* **Gauge Suction Well.** Gauge suction well to determine extent of sand and mud sedimentation.

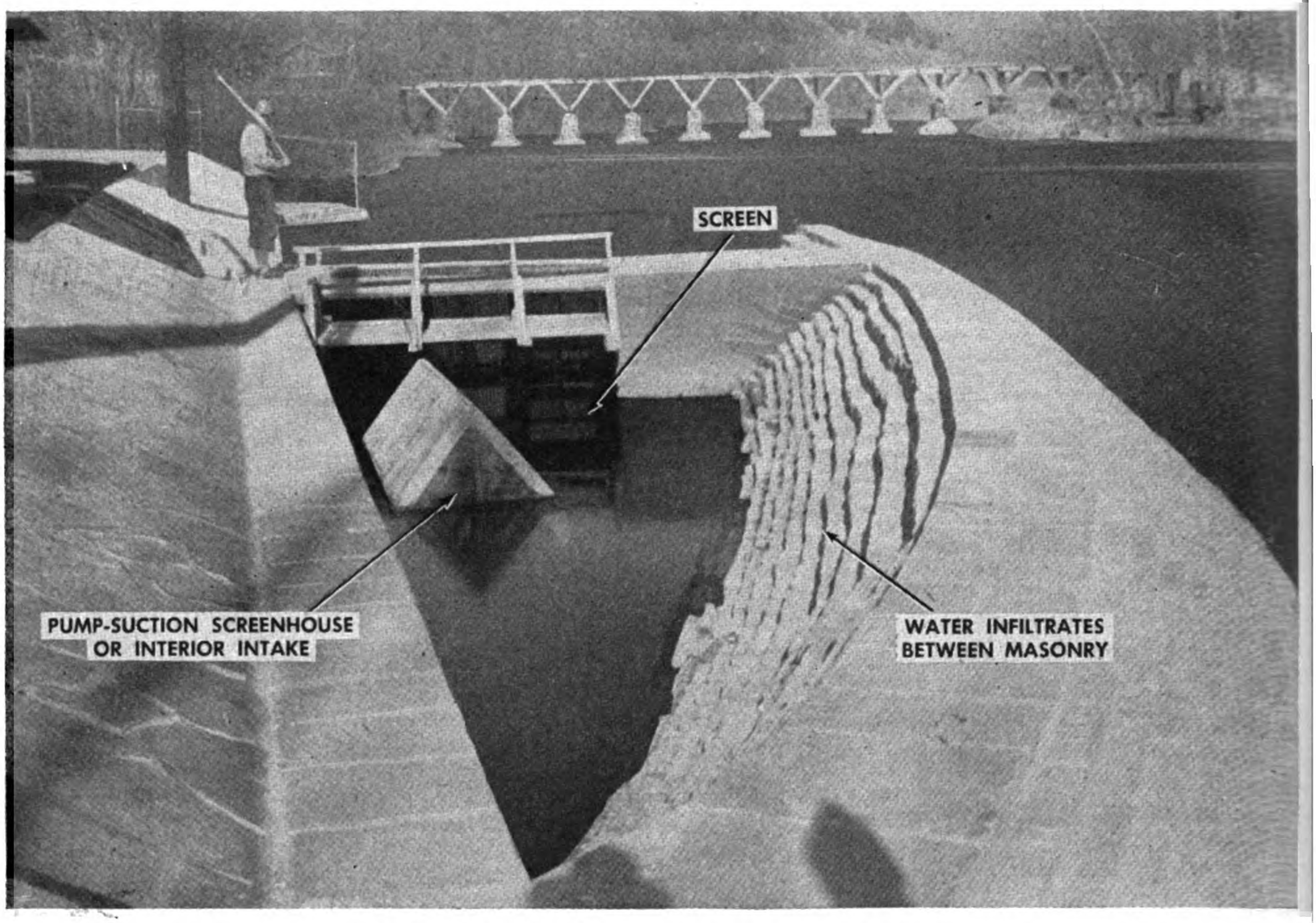

Figure 28. River intake. Screens must be kept clean.

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

SECTION IX
PUMP PERFORMANCE

39. Efficiency and Capacity

Pumping equipment normally operates with little trouble if it is properly maintained in accordance with instructions below. Pumps handling chemicals or abrasive solutions may require more frequent inspections and preventive maintenance operations than shown, and schedules should be modified on the basis of actual operating experience.

1 *a.* **Inspect Driving Equipment.** For preventive maintenance on electric motors, see paragraph 16. See section IV for servicing combustion engines, couplings, drives, and bearings.

1 *b.* **Check Operating Conditions.** To maintain a pump properly, operators must learn to recognize normal sounds and operating conditions of a properly running pump and to investigate immediately any change in these sounds or operating conditions. As a matter of routine, they make the inspections below during their regular tours of duty. Whenever practicable, tours should be made at least once an hour.

(1) Check bearing temperatures and lubrication (see par. 7).

(2) Note readings of suction and discharge pressure gauges if pump is so equipped, and determine cause for any unusual changes in pressure.

(3) Be sure all valves are wide open or properly set and screens are not clogged.

(4) Examine packing.

(5) Observe rate of flow if pump output is metered and investigate cause of any unusual changes.

(6) Check readings of instruments and meters on pump motor and determine cause for any changes in their values.

(7) Note direction of rotation.

2 *c.* **Check Wearing or Sealing Rings.** These rings seal discharge water from suction water in rotating pumps. They are not perfect seals and some leakage is permissible, but excessive leakage caused by worn sealing rings seriously affects pump efficiency. Therefore proper wearing-ring clearance is extremely important. In the straight type wearing ring (fig. 29①), the most common type, diametrical clearance need not be less than 0.025 inch and should not be greater than 0.050 inch. In the L-shaped type (fig. 29②), clearance in the space parallel to the shaft should be the same as for the straight type. However, clearance of the space at right angles to the shaft must be governed by end-play tolerances in the bearing. For specific information on clearances for L-shaped and labyrinth types (fig. 29③), consult the pump manufacturer.

3 *d.* **Check Pump for Cavitation.** Cavitation generally results from improper pump design or improper use of the pump under head conditions imposed on it.

(1) *Effect.* Cavitation causes severe pitting and a characteristic spongy appearance in the metal. It generally affects the entrance portion of the impeller, though it may also occur on the casing. Figure 30① shows the effect of cavitation on a mix flow pump impeller; figure 30② shows the effect on a double-suction centrifugal-pump impeller.

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(2) *Cause.* Cavitation occurs on any surface exposed to flowing fluid when the velocity of the fluid causes its absolute pressure to drop to its vapor pressure and subsequently increase. The extreme velocities which create cavitation in pumps are generally due to turbulence and eddy currents near the boundary surfaces of the impeller, portions of the casing, and guide vanes. When the critical velocity is reached the fluid vaporizes, forming vapor pockets

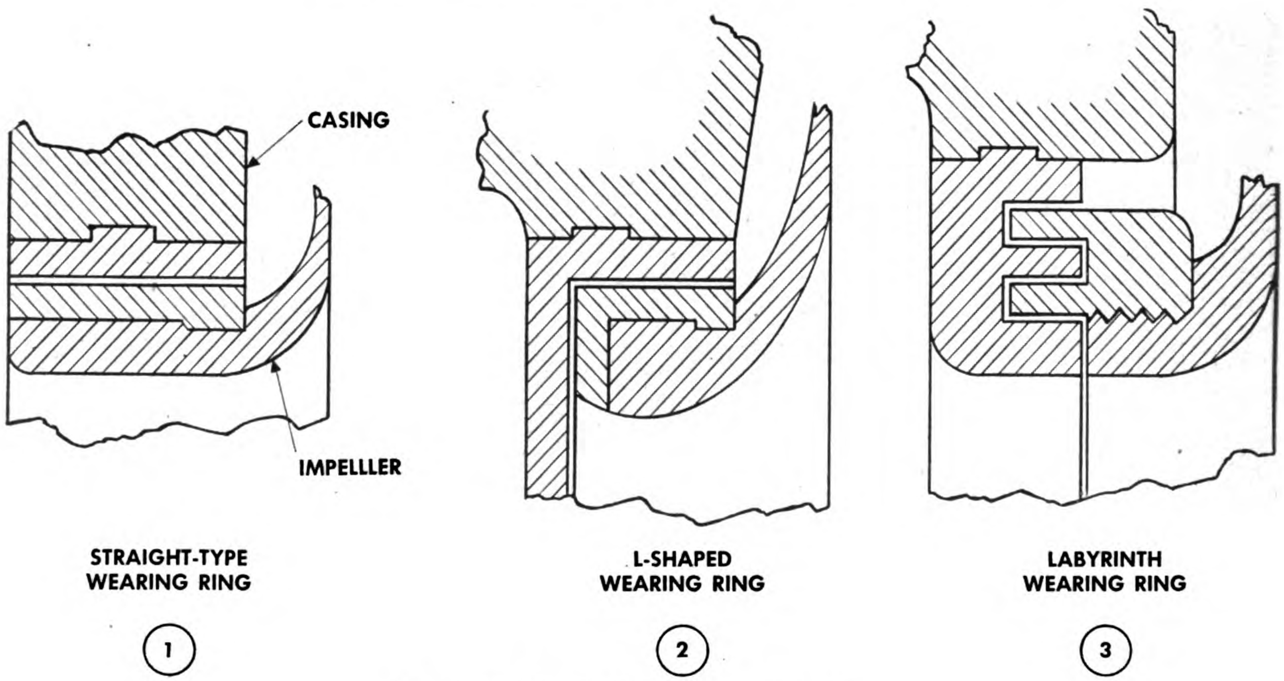

Figure 29. Types of wearing or sealing rings.

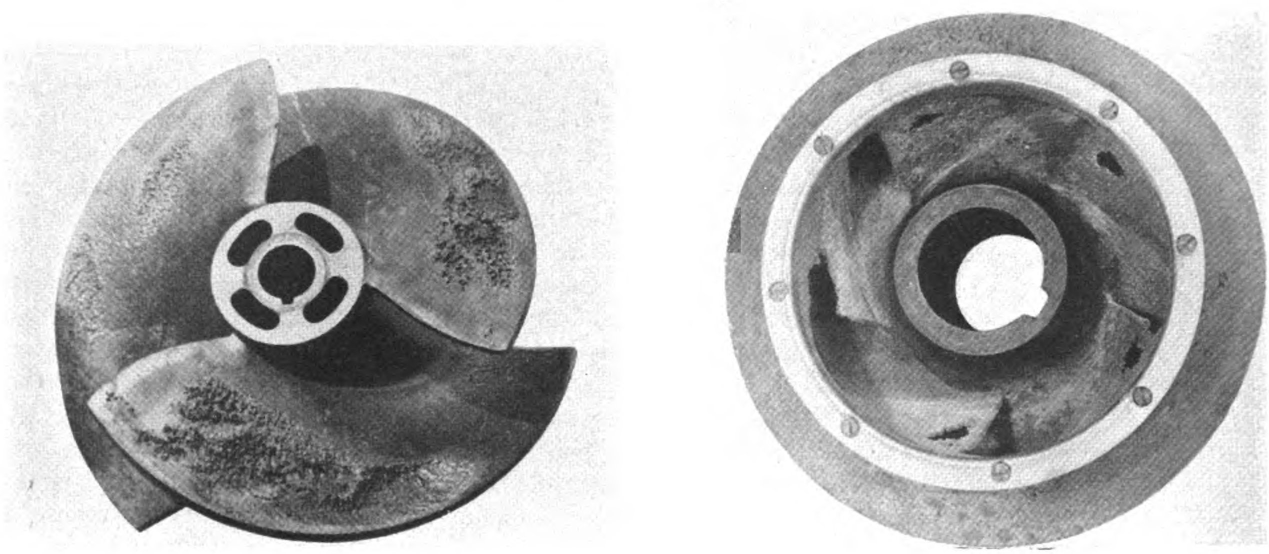

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Figure 30. Pump impellers showing typical effects of cavitation.

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which disturb the flow; when these pockets collapse, vibration and destruction of surrounding walls results.

(3) *Remedies.* Basic errors in design or use of a pump subject to cavitation must be corrected or periodic replacement of cavitated parts will be necessary. Cavitation can generally be corrected by lowering the pump and reducing the suction lift, since this increases static pressure in the pump suction. A possible cause of cavitation may be excessive friction loss in suction piping; therefore, foot valves, check valves, and fittings should be checked. Changing to a larger pipe reduces friction losses and may eliminate cavitation. If basic causes of cavitation cannot be eliminated by any practical means, metal destroyed by cavitation can sometimes be successfully restored by welding processes or metal spray.

4 *e.* **Test Performance of Pump.** Determine the pump's efficiency and capacity, using accurate instruments and gauges and making all determinations accurate to 3 percent if possible. During the test, simulate average normal operating characteristics as closely as possible. For example, run the test with the same rate of flow and operating pressure that is most often used in normal operation. Data obtained from the tests help in controlling operating costs and locating defects in equipment or its use. Tests also show whether or not a deep-well pump should be pulled. The larger the pump and the more continuous its operation, the more important are these tests. The following data are needed to test performance: rate of flow; total head (pressure in feet of water); power input; and speed.

(1) *Rate of flow.* Rate of flow is measured in gallons per minute (gpm), million gallons per day (mgd), and cubic feet per second (cfs). It may be determined by use of a rate-of-flow meter, a totalizing meter, or measuring the gain or loss in a reservoir tank or basin.

(*a*) With a rate-of-flow meter, rate can be read directly on the meter dial.

(*b*) When a totalizing meter is used, it must be the type which gives a reading of total quantity delivered in gallons or cubic feet. Delivery must be timed accurately with a watch.

(*c*) If there is a convenient inlet, discharge basin, or tank from which or into which the fluid can be pumped, rate of flow can be measured by gain or loss in the reservoir, tank, or basin. Make sure the gain or loss represents total delivery of the pump. Use a time interval which is long enough and measure enough change in quantity to permit computations accurate to at least 3 percent. If necessary use one or more hook gauges to get desired accuracy in measuring change in water level. Be sure volume of the basin or tank can be calculated to the same accuracy as other determinations. If too great a change in pumping head results from change in level in the measuring reservoir, this method gives only an average rate of flow for a varying pumping head.

(2) *Total head.* Total head of a pump is its static head plus its total dynamic head (tdh), which is calculated by the equation: tdh = discharge pressure − suction pressure − velocity head on suction + velocity head on discharge. Add and subtract algebraically, using plus signs for positive pressure and minus signs for "negative" pressure (pressure below atmospheric).

(*a*) Measure pressures with accurate, recently tested gauges. If a pressure gauge is used, connect it as closely as possible to the suction and discharge

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flanges of the pump. Convert pressure-gauge readings from pounds per square inch to feet of head by multiplying by 2.31.

(*b*) Since a gauge measures pressure at its own center line, a reference point must be selected on the pump; the pump center line is a convenient reference. After converting gauge pressure to feet of head, correct it so final figure represents pressure at the reference point. If the gauge is below the reference point, subtract the vertical difference in feet from the gauge reading; if the gauge is above the point, add the difference. Make this correction algebraically: use plus sign for positive pressure and minus sign for negative pressure (suction lift).

(*c*) Use a vacuum gauge if suction pressure of the pump is negative. If the gauge is calibrated in inches of mercury, multiply by 1.13 to convert to feet of head.

(*d*) Velocity head is found by the equation: velocity head$=\frac{V^2}{2G}=\frac{V^2}{64.4}$ where V is the average velocity of flow in the pipe in feet per second at the point where the pressure reading is taken.

(*e*) Static head is less than tdh, the difference being friction loss in piping. Static head is the vertical difference in feet between the free level of the source of supply to the pump and the point of free discharge, or to the level of free discharge of discharge water.

Note. Excessive friction losses in piping are as serious as inefficiency in the pump. Check friction loss tables for pipe and suction and discharge fittings, and make necessary adjustments.

5 (3) **Power Input**. (*a*) *Electric drives*. If the motor is equipped with an indicating wattmeter or a recording wattmeter, read power input directly from the instrument. If a watt-hour meter is installed, both kilowatt-hours and kilowatts should be determined; kilowatts can be determined by timing the meter. The black figure on the top side of the disk shows number of kilowatt-hours per revolution. If power input is read for the same interval of time that quantity of water is measured, an average efficiency can be determined for the quantity of water delivered during the tests. If no permanent instruments are installed, a portable recording wattmeter or watthour meter can be used. If these are not available, use an ammeter to measure current input to the motor. This reading should be compared with the name plate rating of the motor. Voltage should also be measured, as undervoltage can cause overloading.

(*b*) *Internal-combustion engines*. It is not possible to determine actual power delivered by internal-combustion engines. However, by measuring fuel consumed during the test and comparing findings with previous tests and average fuel-consumption data for engines of similar type, power input can be approximated. Fuel consumption can be measured by drop in level of fuel storage tanks. If this is not sufficiently accurate, small auxiliary test tanks can be used. If the engine operates on gas, a volumetric or an orifice type gas meter is needed for the determination.

(4) *Speed*. (*a*) *Rotary speeds*. Rotary speeds are measured in revolutions per minute (rpm). To find rpm, use a revolution counter and stop watch, a speed indicator, or a tachometer.

(*b*) *Reciprocating speeds*. Reciprocating speeds are measured in strokes per minute. Reciprocating pumps are usually driven by rotary drives. After determining the speed reduction, rotary speed can be measured and the number of strokes per minute computed. A direct connection to a crank and crosshead mechanism is generally employed. In computing the delivery per stroke, be sure to differentiate between single-acting and double-acting pumps. In single-acting pumps, the number of strokes per minute equals rpm of the crankshaft; in double-acting pumps, the number of strokes per minute equals twice the rpm.

(5) *Computations.* (*a*) *Kw output.* Output of the pump in kilowatts is computed by the following equation:

$$\text{kw output} = \frac{\text{gpm} \times \text{tdh} \times 0.746}{3960}$$

Where: *gpm* = gallons per minute.
tdh = total dynamic head in feet.
0.746 = number of kilowatts in 1 horsepower.
3960 = number of foot-gallons in 1 water horsepower.

(*b*) *Efficiency of electric drive.* Efficiency of an electric drive is computed by the following equation:

$$\text{Efficiency} = \frac{\text{kw output of pump} \times 100}{\text{kw input to motor}}$$

(*c*) *Internal-combustion engine.* The best measure of performance of an internal-combustion engine is the fuel consumed per kilowatt-hour of useful work done (output of the pump). If head-capacity data conform to the manufacturer's characteristic curve (*g* below) then efficiency indicated for the test delivery can be used for computing input power to the pump shaft. Allowing for losses in the drive (V-belt, gear reducer, etc.), fuel consumption per kilowatt-hour of motor output can be computed. It should be approximately within the following ranges for various fuels:

Gasoline: 0.6 to 0.7 pounds of fuel per kilowatt-hour.
Diesel: 0.55 to 0.65 pounds of fuel per kilowatt-hour.
Gas: 17,500 Btu per kilowatt-hour.
(Natural gas has approximately 1,000 Btu per cubic foot.)

(*d*) *Pump efficiency.* Pump efficiency can be computed from the following formula:

$$\text{Efficiency} = \frac{\text{tdh} \times Q \times 8.33}{\text{bhp} \times 33{,}000}$$

Where: tdh = total dynamic head in feet.
Q = rate of flow in gpm.
8.33 = weight of one gallon of water.
bhp = brake horsepower.
33,000 = number of foot-pounds in 1 horsepower.

f. **Use of Data.** Compare test data with the manufacturer's characteristic curve for the pump and investigate any wide differences. Motor efficiency of an electric driving motor can be obtained from the motor manufacturer. By dividing it into the wire-to-water efficiency computed for the unit, pumping efficiency can be obtained. This also can be plotted on the characteristic curve and its value compared. It should be noted that speed of a centrifugal pump is important and must be known when making a comparison with a curve. Data

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obtained for one speed can be determined for any other speed fairly accurately by the following relations:

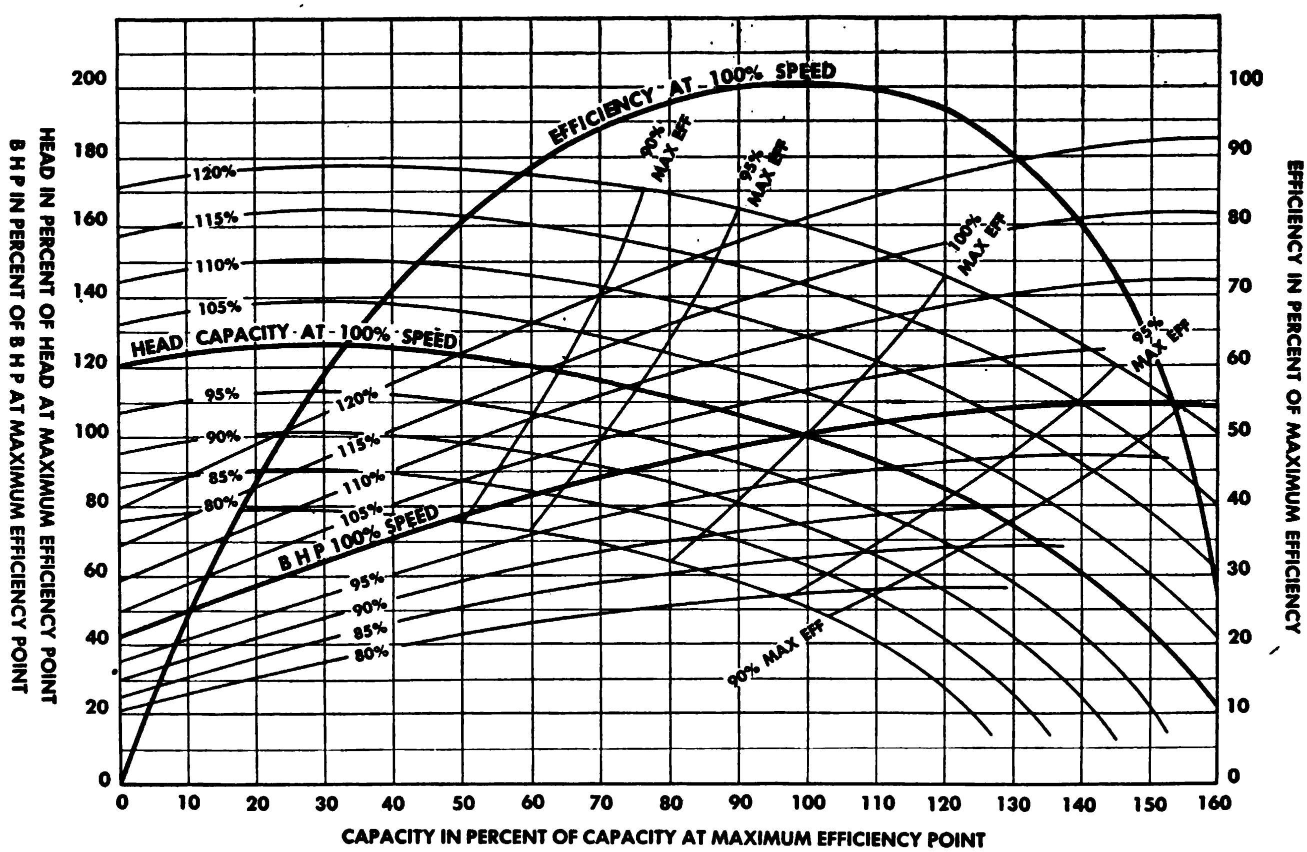
Capacity or delivery is directly proportional to speed.

Head is proportional to square of the speed.

Power is proportional to cube of the speed.

To construct the efficiency curve, compute pump efficiency (*e*) (5) (*d*) above) for several points on the head-capacity curve and connect them with a smooth curve. For typical characteristic curve for centrifugal pumps, see figure 31. Other types, such as axial-flow and mixed-flow pumps, have slightly different modifications of this curve. The outstanding difference in the case of mixed-flow and axial-flow pumps is that the brake horsepower increases with increasing head.

g. Characteristic Curves. A graph showing the head, capacity, and brake horsepower for a pump is known as a characteristic curve. Head is the total dynamic head. Capacity is the delivery of the pump in gpm or other suitable rate-of-flow unit. Brake horsepower is input horsepower to the *pump shaft*, not to the *motor;* for directly connected motors, it is the motor output. If an intermediate drive is used, efficiency of the drive must be considered. Pump efficiency can be computed from these same values; the efficiency curve is usually included in the characteristic curve.



CHARACTERISTIC CURVE, CENTRIFUGAL PUMPS

Figure 31.

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY

h. Determination of Field Pumping Head. Field pumping head in deep-well pumps pumping against an above-ground head or discharging at the surface of the ground can be determined as follows:

(1) When unit is operating against above-ground head, compute total field head, not including pump column friction by adding lift in well or pumping level to total head above ground. Lift in well equals static level in well plus drawn-down. Total head above ground equals gauge reading in feet, including friction in pipe line *A*, plus distance *B* (fig. 32). If no gauge is available, measure head above ground in feet and add estimated pipe-line friction.

When writing factory for help on operating problems, list all pipe lines, giving diameters, lengths, age, condition, and all fittings.

(2) With no head above ground (dotted lines, fig. 32), compute total field head, not including pump-column friction, by adding draw-down to static level in well.

40. Rotating-shaft Packing

a. General. The following general packing recommendations are a guide in selecting the correct type of packing for more common pumping services for use with water below 220° F.:

(1) Woven or braided cotton or asbestos, nonreinforced.

(2) Semimetallic plastic.

(3) Combination of (1) and (2) above.

b. Manufacturer's Assistance. When requesting specific recommendations from the packing manufacturer, give him enough detailed information to enable him to select the proper packing. The following information should be supplied:

(1) Description of liquid handled, including percentage concentration, and impurities.

(2) Amount of suspended abrasive matter present, if any.

(3) Stuffing-box pressure and temperature.

(4) Speeds.

(5) Stuffing-box dimensions including depth of box, outside diameter, and diameter of shaft or shaft sleeve.

(6) Location and width of sealing cage (lantern gland), if any.

(7) Shaft or shaft-sleeve material and hardness.

c. Packing the Stuffing Box. Before packing a stuffing box, make sure box is clean and all old packing is removed. If box has a seal cage, make sure it is located opposite the sealing liquid inlet tap. To do this, measure the depth of box and location of sealing liquid inlet tap. Then place enough rings of packing in bottom of box so when packing is compressed the seal cage will be in its proper position. Always stagger ring joints.

(1) *Woven and braided packing.* Rings of woven and braided packing need not be compressed individually. Dip each ring in oil and push it into bottom of box. When box is half full, draw rings up snug by taking up on packing sleeves and gland. Pack remainder of box, draw up snug, and then back off gland until fingertight. Packing expands with heat so a box that is more than fingertight when cold will generally smoke when equipment is started.

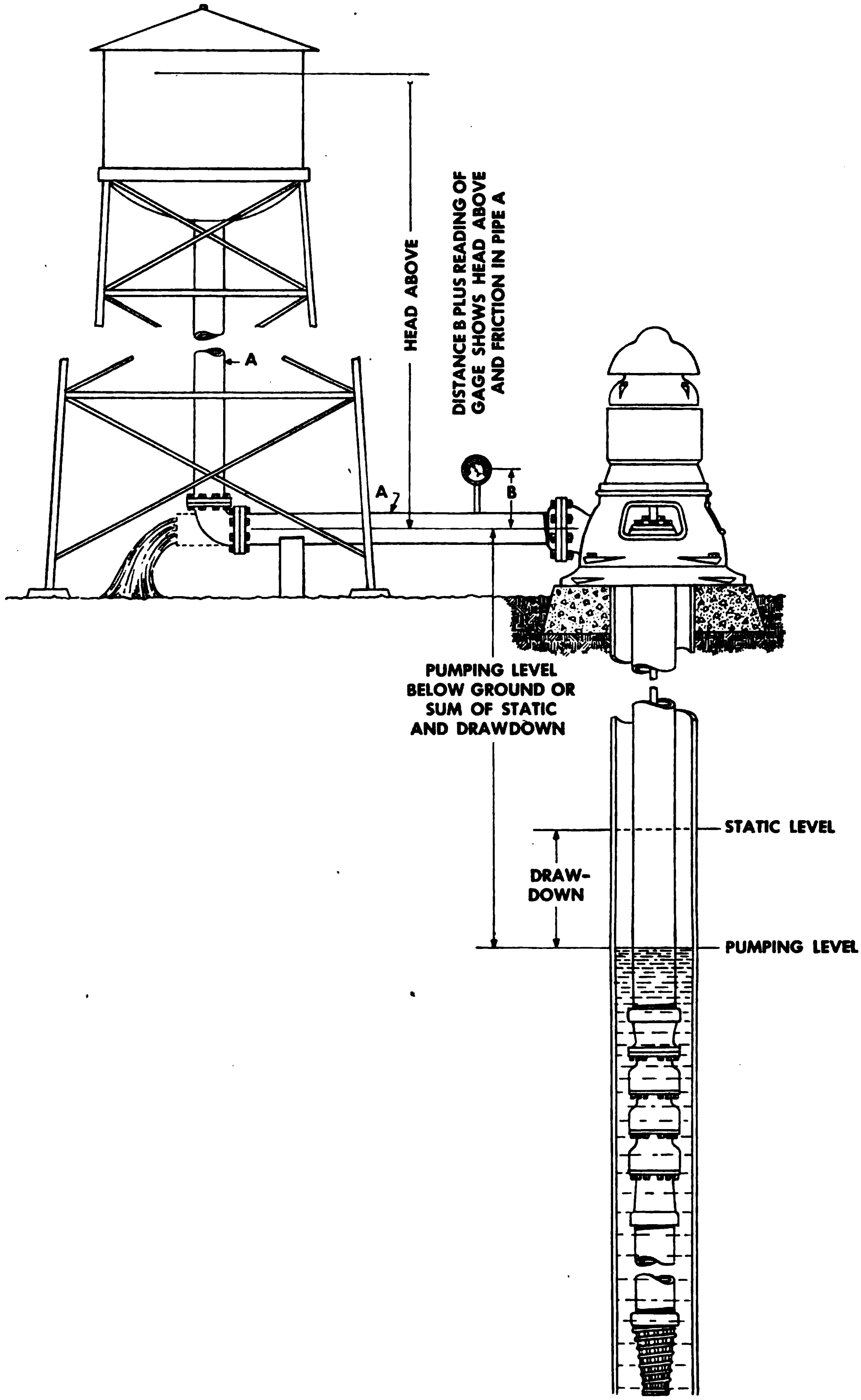


Figure 32. Measuring total head.

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(2) *Plastic and metallic packing.* Rings of plastic and metallic packings must be compressed individually. Dip each ring in cylinder oil before inserting in box and draw each ring up tight by means of split packing rings and gland. Then give shaft a few turns by hand to gloss the packing. Nonjacketed plastic rings squeeze under the clearances if placed next to bottom of box or stuffing-box bushings, seal cage, or glands. Always use metallic or jacketed rings at these locations.

(3) *Combinations of packing.* Follow the packing arrangement sheet supplied with the packing when installing combination sets. Combination sets usually consist of one or more rings of metallic or semimetallic packing installed on each end of the set, with intermediate rings of plastic or other types of soft packing.

d. Lubricating Packing. Drip leakage is needed to insure proper lubrication throughout the packing box. In installations pumping nonlubricating, corrosive, or highly volatile liquids, an external means of lubrication must be provided. This can be done by means of a grease seal or by injecting a suitable sealing liquid into a seal cage located at an intermediate point in the stuffing box. For volatile hydrocarbons, oil injection or circulation should be used.

e. Checking Stuffing Boxes. Packing is a close-fitting bearing and therefore requires lubrication either by leakage or by substitute means. Watch stuffing boxes carefully when starting operation. At the first sign of heating, shut down the unit and allow boxes to cool off before restarting. Several starts may be necessary before leakage breaks through and the box runs cool. Do not back off the glands on a hot box, for this only allows the complete set of packing to move outward as a cylinder, pushed from behind by the liquid pressure, and results in leakage around the outside of the packing. On turbine-driven units, packing may be broken in at reduced speed if the unit is not run at less than approximately one-third of rated speed. Bring the turbine unit up to breaking-in speed rapidly, because the head developed by a pump varies as the square of the speed and at reduced speeds leakage across the wearing-ring fits becomes dangerously low. Take particular care with multistage units because of their longer bearing spans and greater number of wearing-ring fits.

f. Adjusting the Packing. Keep packing adjusted so a small amount of leakage of the liquid handled or of the sealing liquid is injected into the center of the stuffing box at the seal cage. Before inspecting packing leakage on units with smothering glands, turn off the smothering water. Draw gland bolts up one flat at a time; leave enough time between each turn for the pressure to be transmitted through the packing and for the effect on leakage to be observed. When repacking stuffing boxes, be sure all old packing has been removed and shaft or shaft sleeve has not been damaged. Sometimes a number of the old rings may be used in repacking the box, but usually all new packing is recommended. Never try to repack a pump by renewing only the last three or four rings.

g. Maintaining Patented Seals. Some pumps have patented seals which do not have the conventional follower and pliable replaceable packing. For specific maintenance details consult the manufacturer.

1 *h.* **Inspect Packing.** Plan to inspect packing at the same time as the annual pump overhaul whenever possible. However, packing must be inspected an-

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nually even if conditions do not permit overhauling the pump. The procedure below applies to rotating and reciprocal type rods.

(1) Relieve pressure from lantern gland and remove followers, packing bolts and nuts, all old packing, and the lantern gland.

(2) *Examine sleeves or rods.* To permit examination of condition of a pump sleeve, disassemble the pump. Replace or refinish worn or grooved sleeves. Refinishing in a lathe is permissible if grooving or wear is less than $\frac{1}{32}$ inch. Take care not to permit so much clearance at base of gland that packing can escape. A brass ring can be machined and inserted in packing gland to prevent loss of packing. Worn sleeves can be replaced with new ones or restored by welding or metallizing.

(3) Inspect follower, bolts, and lantern glands. Clean follower bolts and nuts thoroughly and lubricate them with a light oil so they work easily. Clean follower and lantern gland thoroughly. If latter is rust-susceptible, coat it with a suitable paint or protective coating.

2 *i.* **Check Sealing-water System.** Disassemble sealing-water lines and valves to make sure water passages are open.

* *j.* **Repack Pump.** Use packing recommended by pump or packing manufacturer. Cut packing so joints are square after packing is bent around shaft. Take extreme care in cutting the first piece and use it as a pattern for the others. Use follower, lantern gland, and a few convenient equal length spacers to compress each piece of packing firmly into gland before inserting next piece. Stagger cuts in packing. Be sure lantern gland is centered under water supply connection. After last ring is installed, leave follower nuts fingertight.

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

SECTION X
WELL PUMPS

41. Turbine Type Pumps

Turbine type well pumps have either open or inclosed impellers and either water- or oil-lubricated shaft bearings (figs. 33 and 34). Maintenance and trouble-shooting procedures for these pumps are discussed in *i* below.

1 *a.* **Lubricate Bearings.** (1) *Oil-lubricated pumps and bearings.* Use NS 2110 or NS 2135 to lubricate line-shaft bearing on oil-lubricated, inclosed line shaft pump. See that oil tubing and lubricators are filled. Check solenoids for proper operation. Keep oilcan handy. Check oil level in sight lubricator for underwater bearings. See that oil feed is at average rate of 3 to 4 drops per minute. If in doubt on proper oil-feed rate, consult manufacturer.

(2) *Water-lubricated pumps and bearings.* Lubricate water-lubricated pump with clear water and see that prelubricating tank is full when in use. When filling with pump, close valve when tank is full. Open lubrication valve and allow water to reach bearings before starting pump. If lubricated from main pressure, close valve after starting. If pumps operate automatically and prelubrication delayed solenoid valve is used, allow 1 minute delay and check lubricating valves for proper operation. Check prelubrication control on pumps which have safety controls to prevent their starting before prelubrication water is turned on. See that water flows to bearings when this equipment functions. Check time-delay relay for proper functioning and compare with manufacturer's recommendation. Check solenoid valve and packing. Clean and lubricate linkages and guides.

2 *b.* **Adjust Impellers.** Check impellers for maximum-efficiency setting and adjust if necessary. On hollow-shaft motors, adjusting nut is on top of motor. See manufacturer's instructions for detailed adjustment. Method of adjusting impellers on typical pumps is given below. (See also *i* (4) and (5) below.)

(1) *Closed impeller pumps with sealing rings.* See typical inclosed impeller pump shown in figure 34. Raise shaft by turning adjusting nut until shaft can no longer be rotated freely by hand. Back off nut and lower shaft one-fourth to one-half the total vertical clearance of pump. In an extremely deep well, adjust impellers again if necessary after first few hours of operation.

(2) *Open or semi-inclosed impeller pumps.* See typical open impeller pump shown in figure 33. To adjust impeller allow for stretch of shaft when pump is running with thrust load on it; see manufacturer's instructions for detailed procedure.

(3) *Pomona turbine pumps.* To determine impeller adjustment on any Pomona turbine operating under average conditions, use chart shown in figure 35.

(*a*) The following data must be known:

1. Total head against which pump is or will be pumping, including heads below and above.
2. Pump setting or length of drive shaft.
3. Size or capacity of pump.
4. Full diameter of shaft.
5. Full diameter of head shaft at adjusting nut threads.

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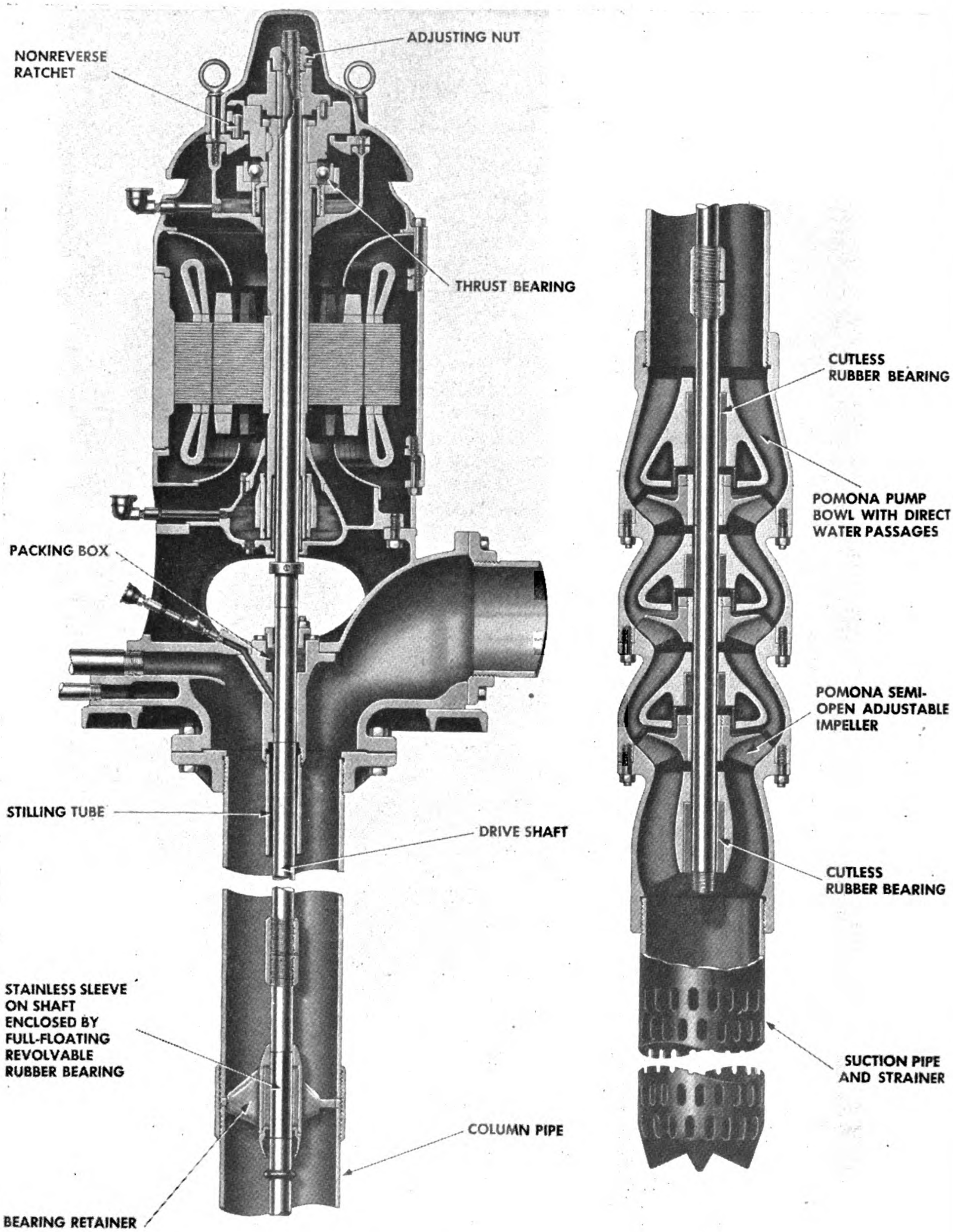

Figure 33. Open-impeller deep-well pump, water lubricated.

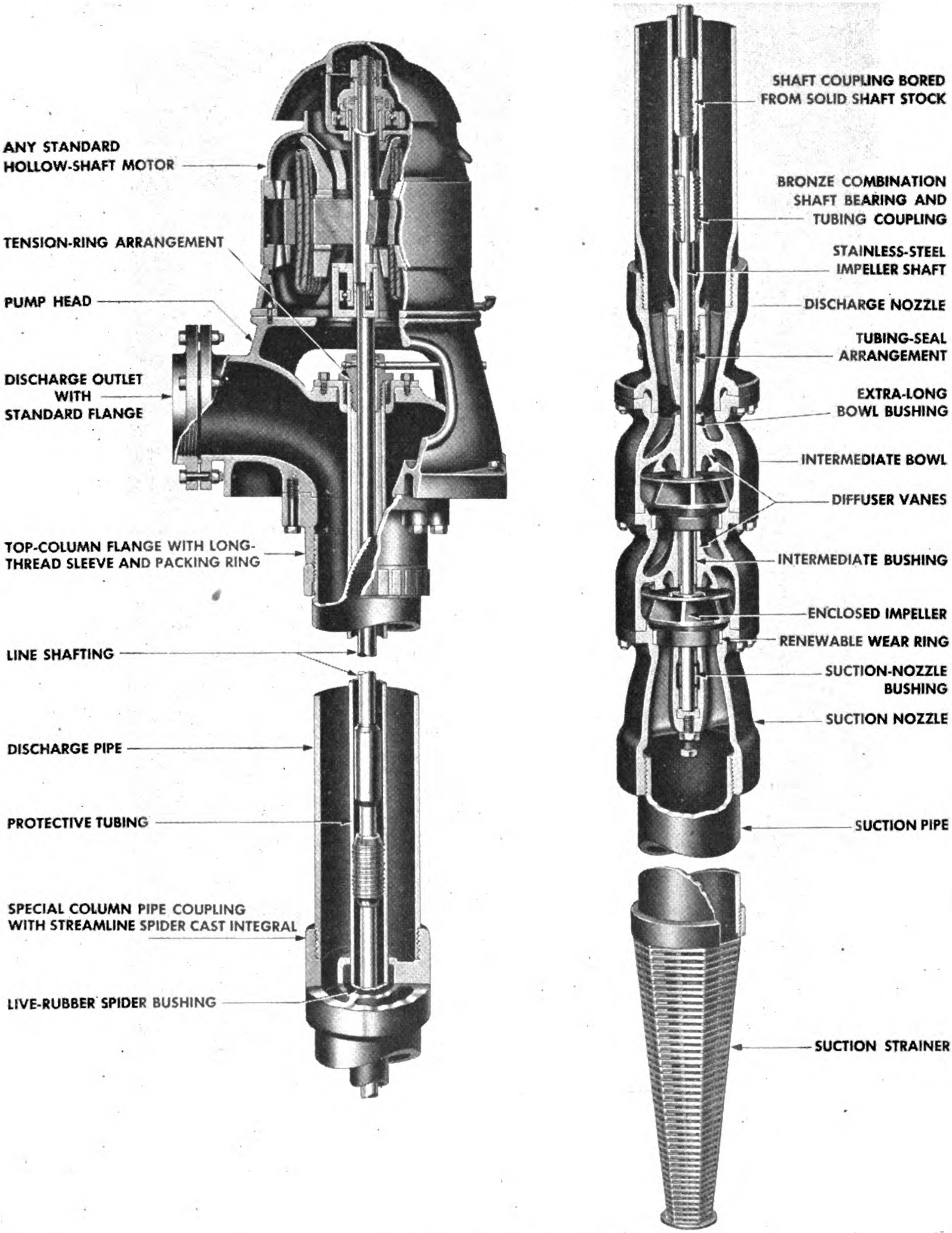

Figure 34. Inclosed-impeller deep-well pump, oil lubricated.

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(*b*) When using the Pomona pump adjustment chart, read from left to right. Always move in straight lines, either vertically or horizontally; never follow diagonal lines. To illustrate use of the chart, the following example is worked out on figure 35. Assume—

Total head is 346 feet.
Pump setting is 230 feet.
Size of pump is 10-inch LC.
Size of shaft is 1½ inches.
Size of headshaft is 1½ inches.

Start at 346 on upper left scale, *Total head*. Drop a perpendicular line down to 230 on *Pump-setting* lines; this is three-fifths the distance between 200 and 250 lines. From this point move horizontally to 10L on *Size-capacity* lines; this represents 10-inch LC pump. Move down to *Shaft-size* line 1½, then move horizontally to *Head-shaft-diameter* line 1½. From this intersection move up to *Impeller-adjustment* scale on upper right and read adjustment in number of faces of the hexagonal adjusting nut; in this problem, intersection is at 14⅝ faces. When adjustment found is a fraction of a face, take the next largest full face; in this example the proper, lowest adjustment would be 15 faces or 2½ turns of the nut. Before starting to turn adjustment nut the required number of faces for proper running clearance, lift impellers off bowl seats to a point where they just barely clear without actual contact when pump is not operating. On some installations this point may be hard to find, but for best results it must be determined accurately. When pump is operating against the given head, proper adjustment gives maximum efficiency, placing impeller as close as possible to bowl seat without actual contact. Impeller adjustment must be recalculated whenever head conditions change.

(*c*) If adjustment obtained from the chart is used on a particular pump operating at the given head and there are still signs that impellers are rubbing slightly on the bottom, stop pump immediately and raise impellers by turning adjustment nut a face at a time until exact clearance has been found. On the other hand, if calculated adjustment does not provide full rated capacity of pump at the given head, stop pump and lower impellers, turning nut one face at a time until lowest possible adjustment is secured.

* *c*. **Overhaul and Inspect.** When any of the conditions below are found, remove pump from well and inspect for worn or damaged parts. Do this work under experienced supervision and follow manufacturer's instructions closely. (See also *i*(7) below.)

(1) Pump shaft fails to turn freely because parts below pump head are binding.

(2) Pump vibrates excessively.

(3) Performance test (see par. 39*e*) shows that capacity or discharge of pump under usual head and speed conditions has decreased 25 percent.

(4) Above-mentioned test shows that loss in efficiency results in $400 yearly increase in cost of power to pump water from well.

* *d*. **Check Clearances.** See that diametrical clearance of wearing rings is no more than 0.050 inch; it need not be less than 0.025 inch. See table VIII for clearances of water-lubricated cutless-rubber bearings.

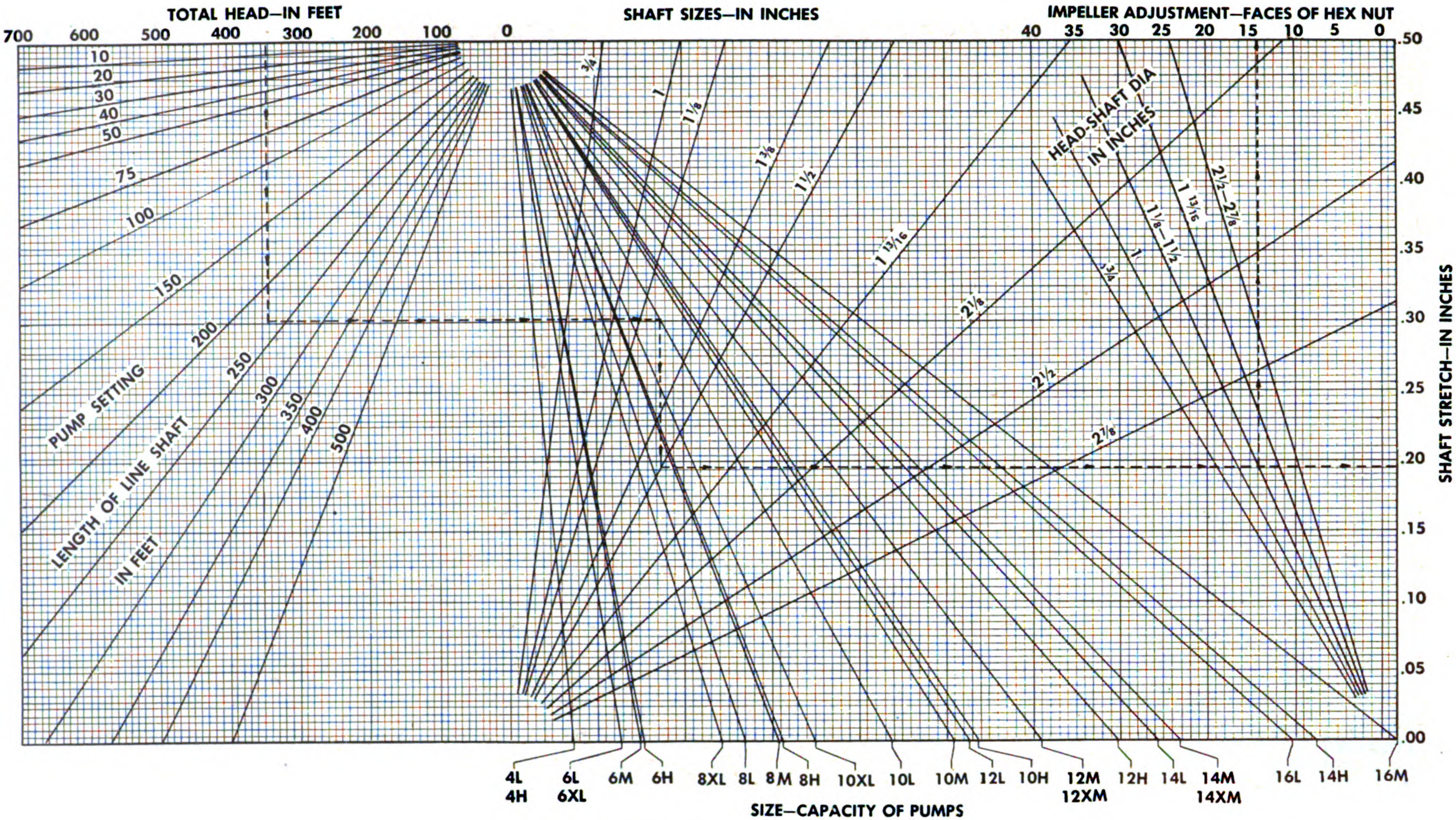

Figure 35. Pomona pump impeller adjustment chart.

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Table VIII. Diametrical clearance of water-lubricated cutless-rubber bearings

Shaft diameter (inches)	Up to 1⅛	1⅛ to 4
Clearance when new (inches)	.020 to .032	.040 to .050
Maximum tolerance (inches)	.040	.070

Allow maximum diametrical clearance of .025 inch on oil-lubricated bearings.

* *e.* **Examine Bowls, Water Passage, and Impellers.** Look for pitting, wear, and corrosion on bowls, water passages, and impellers. Corrosive water affects performance and dependability of pump. Report excessive corrosion to post engineer. If pitting occurs only in lower stage water passages and impellers, cavitation may be taking place; see paragraph 39*d* for cause and remedies. If there is considerable sand in water being pumped, excessive wear results. To reduce sand in effluent, start and stop pump less frequently and reduce the draft on well. Examine and replace parts subject to sand wear if they seem likely to fail before the next inspection is made. Maintain close clearances required for pump efficiency. Consult manufacturer on proper pump clearances. (See also *i*(7) below.)

* *f.* **Examine Shaft Sleeve and Packing Assembly.** See paragraph 40.

4 *g.* **Check Alignment.** See that shaft, pump head, and motor are properly aligned. (See also *i* (5) below.)

5 *h.* **Paint.** Use a good grade of underwater paint or effective protective coating, on exterior of pump and, if practical, on interior parts which are subject to rust. Apply paint to clean dry surface.

i. **Trouble Shooting.** (1) **If pump fails to start,** check for—

(*a*) Low voltage.

(*b*) Burned out fuses, test voltage on phases of motor terminals.

(*c*) Tripped overload relay.

(*d*) Defective motor.

(*e*) Defective starting equipment.

(2) **If motor starts but pump is locked,** check for—

(*a*) Sand-locked pump. Loosen with wrench, or move impellers by adjusting nut on top of shafting.

(*b*) Too tight packing.

(*c*) Improperly adjusted impellers rubbing on top or bottom.

(*d*) Failure to prelubricate rubber bearings on water-lubricated pump, causing them to grip too tightly.

(*e*) Pump forced into well, causing shaft to bind in bearings.

(3) **If pump does not deliver water,** check for—

(*a*) Bottom impeller of pump not submerged. Lower pump.

(*b*) Too slow pump speed. Voltage or frequency may be too low. On belt-drive pump, pulley ratios may be wrong or belt may be slipping.

(*c*) Pump operating above designed head. Reduce head or add additional stage or stages to pump.

(*d*) Suction pipe or impellers clogged. Backwash under pressure through pump; if unsuccessful, pull pump.

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(*e*) Clogged suction strainer. Backwash through pump; if unsuccessful, pull pump.

(*f*) Broken line shaft. Pull column and shafting.

(*g*) Pump running in wrong direction.

(*h*) Closed discharge valve causing pump to build up pressure which shuts off head. Check for possible overload motor under these conditions.

(*i*) Broken or split column pipe.

(4) **If pump is not delivering designed capacity,** check for—

(*a*) Too slow pump speed. Voltage or frequency may be low.

(*b*) Air or gas in water.

(*c*) Leak in suction pipe where pumping level is below bottom impeller of pump.

(*d*) Too great pumping head.

(*e*) Improperly adjusted impellers.

(*f*) Partially clogged suction pipe, suction strainer, or impellers.

(*g*) Partially closed discharge valve.

(*h*) Excessive draw-down. Check water-level readings.

(*i*) Suction lift placed on impellers.

(*j*) Worn impellers. Pull for inspection and repairs.

(*k*) Leak in column pipe.

(*l*) Incorrect gauges.

(*m*) Incorrect meters or capacity-measuring devices.

(*n*) On belt-driven pumps, slipping belt, pulley ratios, wrong or too slow motor or engine.

(5) **If pump uses excess power,** check for—

(*a*) Speed too high because of high voltage or frequency or incorrect pulley ratios or engine controls.

(*b*) Too heavy oil used to lubricate line shafting.

(*c*) Sand in water.

(*d*) Crooked well or shifted casing, throwing lineshaft bearings out of line.

(*e*) Wrong discharge head, for the pump.

(*f*) Kink or bend in line shaft.

(*g*) Vibration.

(*h*) Too tight packing.

(*i*) Improperly adjusted impellers rubbing on top or bottom of bowls.

(*j*) Pump head out of alignment.

(6) **If pump vibrates,** check for—

(*a*) Worn bearings.

(*b*) Kinked or bent line shaft.

(*c*) Motor out of balance. Contact manufacturer.

(*d*) Well out of plumb.

(*e*) Air or gas in water.

(*f*) Motor head shaft out of line with pump shaft, or head shaft bent or sprung.

(*g*) Impellers out of balance, fouled by rags or other foreign matter.

(7) **If there are signs of excessive wear,** check for—

(*a*) Bent line shaft or head shaft.

(*b*) Improper lubrication.

(*c*) Crooked well.

(*d*) Excessive sand in water.

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(*e*) Vibration.
(*f*) Cross-threaded column pipe or line shaft.
(*g*) Misalignment.

42. Air-lift Type Pumps (fig. 25)

3 **Check for air contamination in air lift.** Because well water can become contaminated by air, make sure there are no cross connections in air system by which contaminated water may enter the well. Do not permit air outlets submerged in process tanks or air-tank drains below rim of sewer connections. Check well water for presence of oil from compressed air by looking for oil film on surface of a water sample. Examine compressor for oil pumping if oil appears in sample. Provide filters for air intake of compressor and keep filters clean.

43. Ejector Type Pumps

An ejector well pump consists of a centrifugal pump located above ground, part of whose discharge is bypassed through an ejector located in the well (fig. 36).

† *a.* **Overhaul and Inspect.** (1) For maintenance of ejector portion of pump, see paragraph 41. When ejector, foot valve, and screen are removed from well, examine all parts for wear and corrosion. Check size of nozzle and ejector throat to insure original efficiency. If there is evidence of wear, consult manufacturer for proper diameters. Check foot valve for leakage. Reface seat, replace valve, or reseat if necessary. Renew strainer if necessary.

6 (2) **Disassemble pump.** Examine for wear or corrosion of casing, rings, and impeller. Check to see that diametrical ring clearance is not less than 0.005 inch and not greater than 0.020 inch. If wear or corrosion is so great that failure may occur before next inspection is made, replace the part. See that no water passages are clogged.

7 *b.* **Check Bearing Clearances.** See paragraph 41.

8 *c.* **Check Packing Assembly.** See paragraph 40.

9 *d.* **Check Alignment.** See paragraph 24.

10 *e.* **Paint.** Paint exterior of pump and, if practicable, paint interior iron of pump with a good grade of underwater paint or effective protective coating.

44. Reciprocating Type Pumps

Single-stroke type reciprocating well pumps are operated by a jack which lifts the pump rod up and down. The pump is in the well bottom and consists of a leather cup sealed plunger with a built-in discharge valve and a suction valve at bottom of the well or eduction pipe (fig. 37). Larger types have duplex and triplex plungers operated by separate cranks on the same crankshaft as the jack.

† *a.* **Check Pump Jack.** For maintenance of elements of pump jack, see paragraphs 22, 23, and 25. For more detailed maintenance data, consult manufacturer's instructions.

11 *b.* **Check Pump Delivery.** Measure well output for a known number of strokes. Delivery per stroke should not be less than 90 percent of volumetric displacement of pump (area of plunger times length of stroke). When delivery falls below 50 percent of volumetric displacement, or if water supplied is below post water requirements when delivery is between 50 percent and 90 percent of

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	
						displacement, remove pump from well and examine valves and cup leathers. Before removing pump, lower it, turning clockwise to pick up the foot valve. Consult manufacturer's instructions for further maintenance procedure.
					12	*c.* **Overhaul.** Inspect jack for wear, replacing worn bearings and parts. Perform all maintenance called for in section IV. Paint if necessary. If pump-delivery check is satisfactory, do not overhaul portion of pump in well. Check packing assembly and repack (see par. 40).

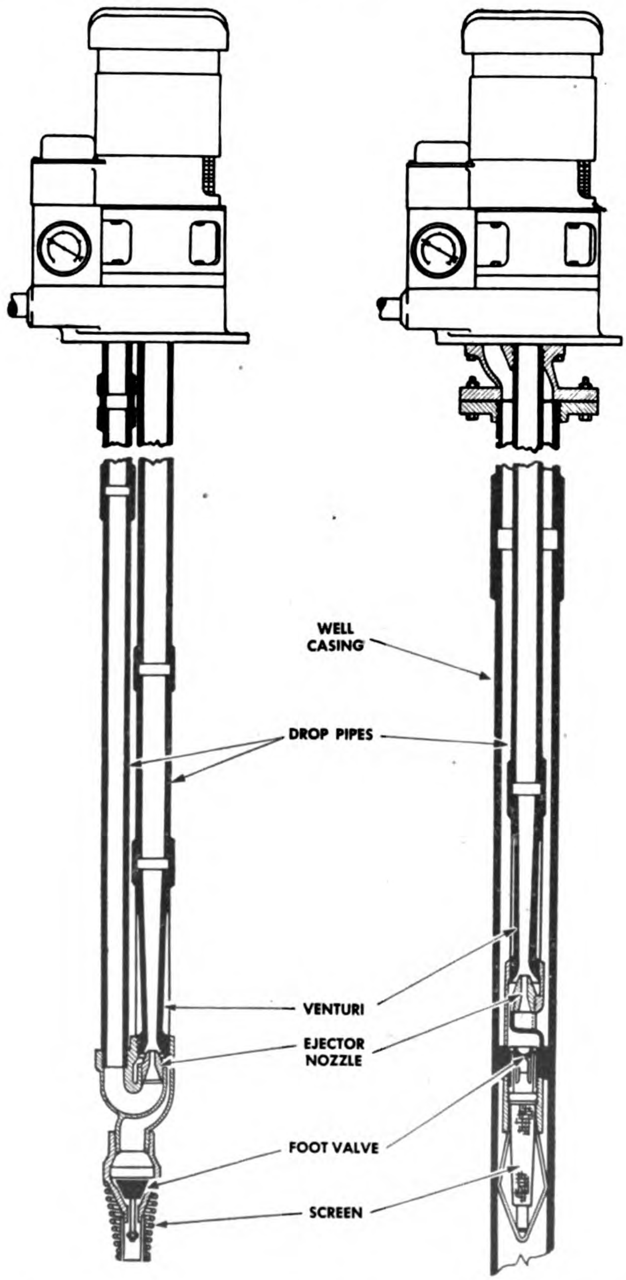

Figure 36. Ejector type well pumps: two-pipe ejector pump (left) and single-pipe ejector pump (right).

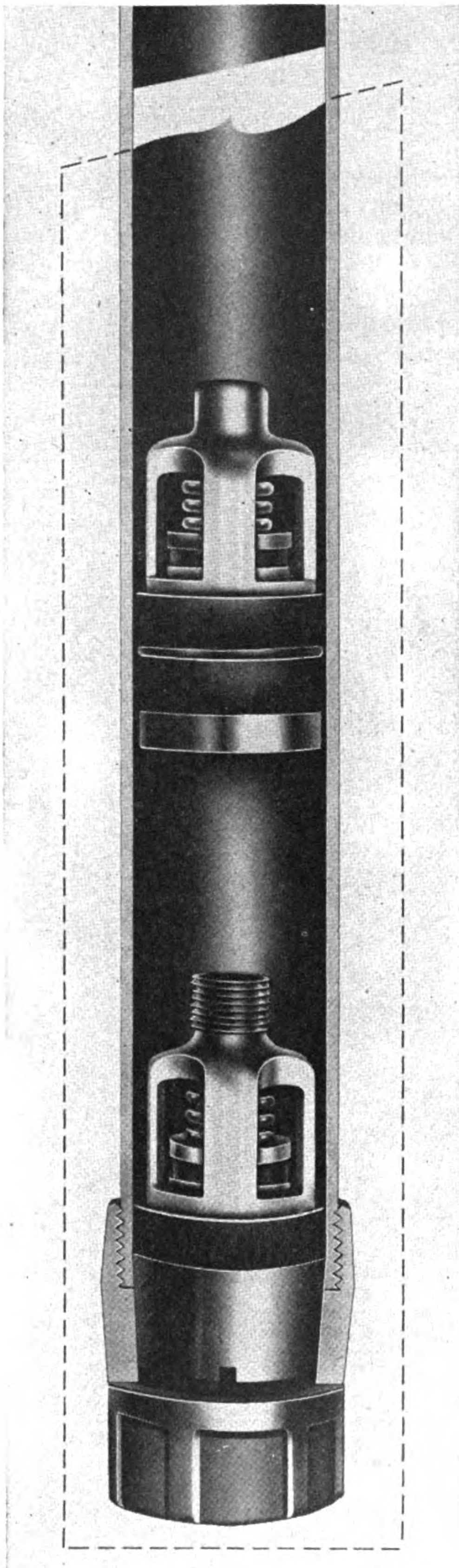

Figure 37. Plunger and foot valve plunger type deep-well pump. Working cylinder is placed in well. Plunger arrangement delivers water on up stroke and returns to position for more water on down stroke.

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SECTION XI
HORIZONTAL AND VERTICAL CENTRIFUGAL PUMPS

45. General

Centrifugal pumps have various forms, including double-suction volute, single-suction volute, two stage and higher, open impeller, and closed impeller (figs. 38 through 42). Many different arrangements of suction and discharge connections are possible. Since detailed services cannot be given for all types, this section contains general preventive maintenance services to be performed at stated intervals. Not all services apply to each pump; list only applicable services when making out the field card.

† For maintenance of drive equipment, checking pump performance, and care of sealing rings and packing, see sections IV and IX.

a. **Trouble shooting.** (1) **If no water is being delivered,** check for—

(*a*) *Improper priming.* Pump and suction pipe not completely filled with water before starting.

(*b*) Speed too low.

(*c*) Discharge head too high.

(*d*) Suction lift too high. Check with gauge.

(*e*) Impeller completely plugged.

(*f*) Rotation in wrong direction.

(2) **If not enough water is delivered,** check for—

(*a*) Air leaks in suction or stuffing box.

(*b*) Speed too low.

(*c*) Discharge head higher than anticipated.

(*d*) Suction lift over 15 feet. Check with gauges.

(*e*) Impeller partially plugged.

(*f*) Not enough positive suction head for hot water.

(*g*) Mechanical defects such as worn wearing rings, damaged impeller, and defective casing packing.

(*h*) Foot valve too small or partially obstructed.

(*i*) Foot valve not immersed deep enough.

(*j*) Rotation in wrong direction.

(3) **If water pressure is too low,** check for—

(*a*) Speed too low.

(*b*) Air in water.

(*c*) Mechanical defects such as worn wearing rings, damaged impeller, and defective casing packing.

(*d*) Incorrect impeller diameter.

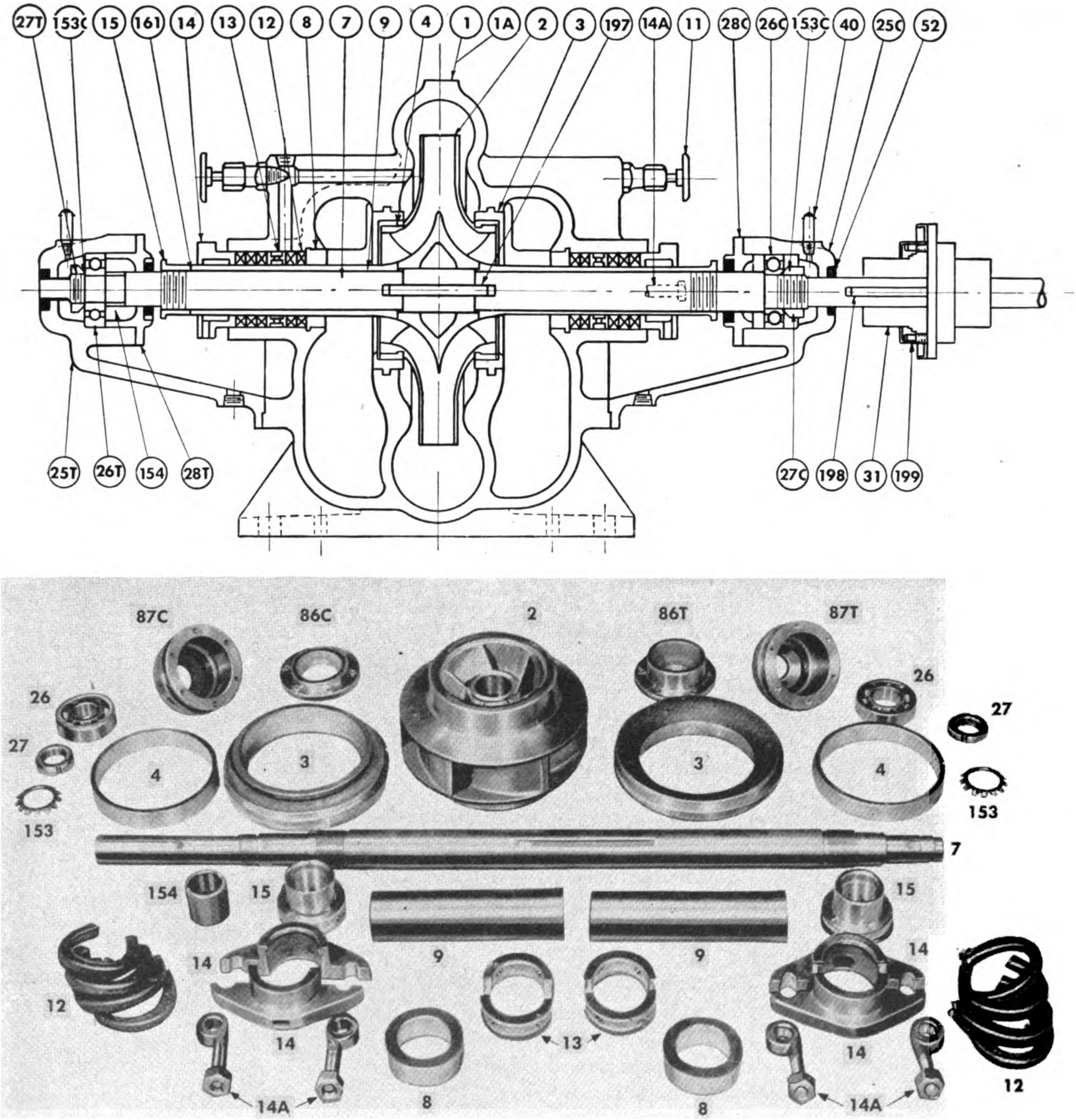
(4) **If pump works for a time and stops,** check for—

(*a*) Leaky suction line.

(*b*) Plugged water seal.

(*c*) Suction lift too high.

(*d*) Air or gases in liquid.



1. Casing.
1A. Casing gasket.
2. Runner.
3. Casing wearing ring.
4. Runner wearing ring.
7. Shaft.
8. Stuffing-box bushing.
9. Shaft sleeve.
11. Water-seal valve.
12. Packing.
13. Water-seal ring (split).
14. Gland (split).
14A. Gland bolt and nut.
15. Shaft-sleeve nut.
26C. Ball bearing.
26T. Ball bearing.
27C. Retaining nut.
27T. Retaining nut.
31. Complete coupling.
40. Grease fitting.
25C. Ball-bearing housing.
25T. Ball-bearing housing.
28C. Ball-bearing end cover.
28T. Ball-bearing end cover.
134. Bearing spacer sleeve.
153C. Lock washer.
52. Grease retainer.
161. Cord packing.
197. Runner key.
198. Coupling key.
199. Coupling spring.

Figure 38. Double-suction volute centrifugal pump.

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY

(*e*) Suction piping and valves not completely freed of air when priming. Possible causes are air collecting in high points in suction line, valve bonnets, etc.

(5) **If pump takes too much power,** check for—

(*a*) Speed too high.

(*b*) Head lower than rating, or pumping too much water.

(*c*) Liquid heavier than water, with high viscosity and specific gravity.

(*d*) Mechanical defects such as the following: casing distorted because of excessive strains from suction and discharge piping; shaft bent; impeller rubbing casing; rotating element binding; stuffing boxes too tight; wearing rings worn; and casing packing defective.

(*e*) Rotation in wrong direction.

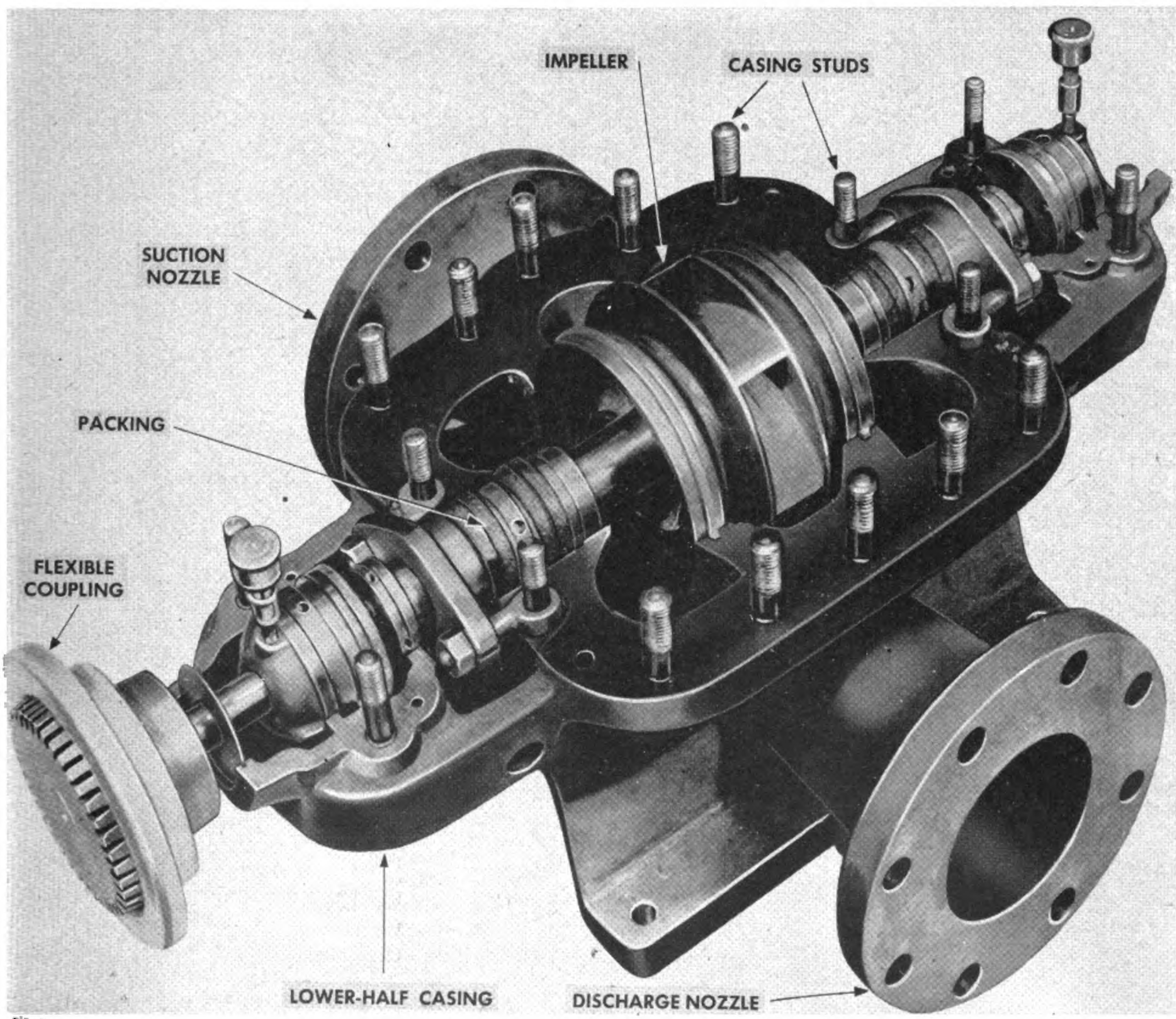
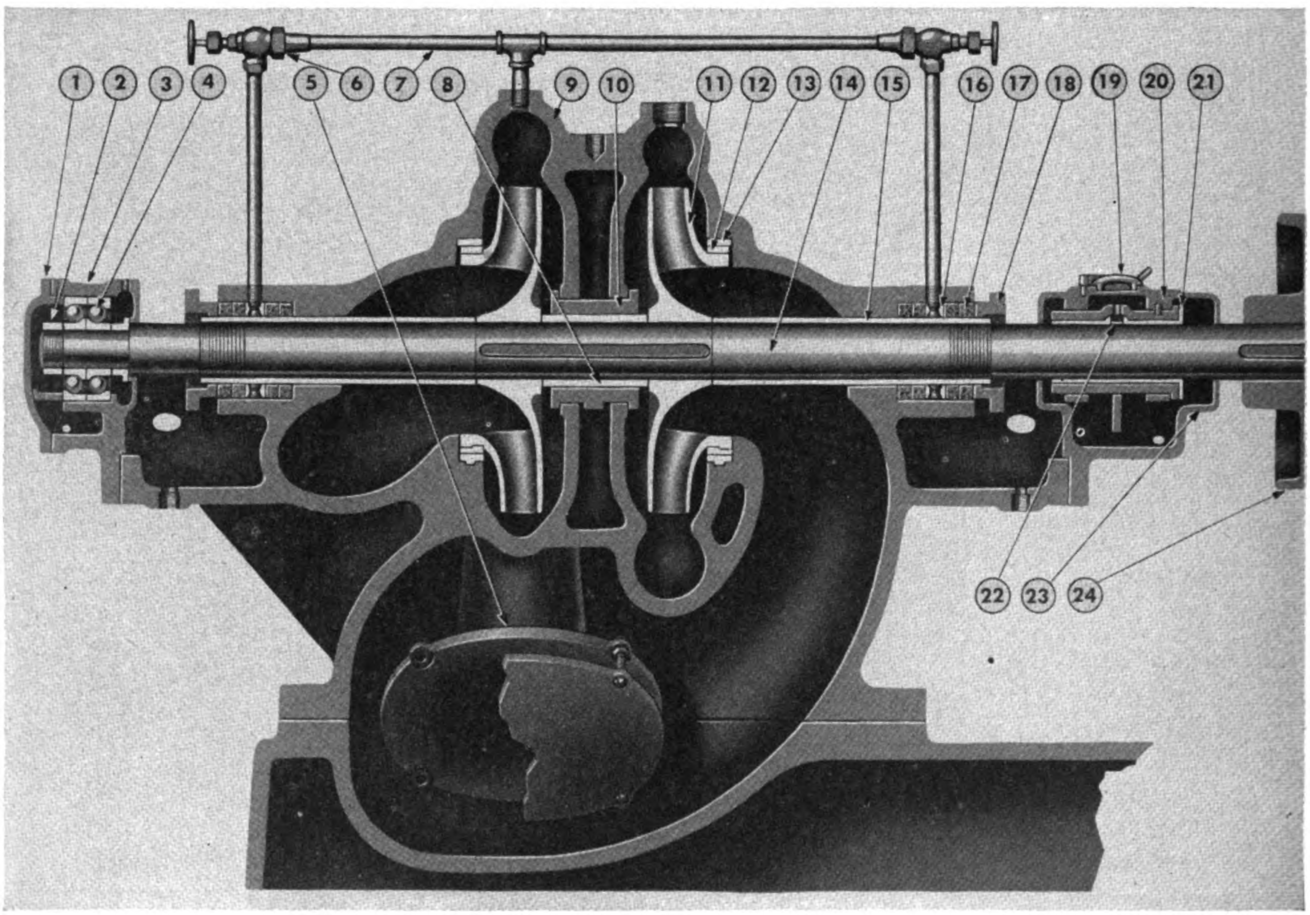


Figure 39. Horizontal split-case double-suction volute pump with side suction and discharge.

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY
1					

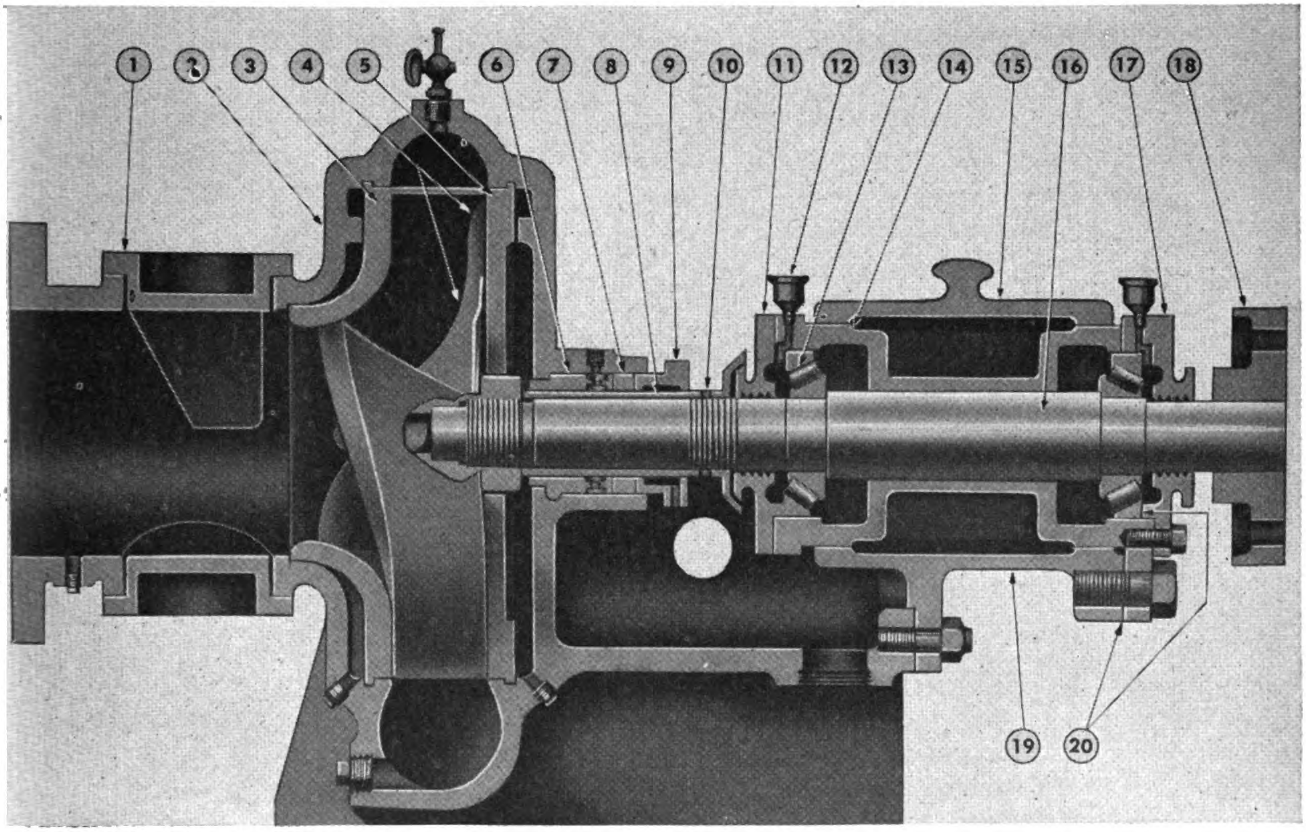
b. **Check Water-seal Packing Glands for Leakage.** Packing box is best protected by a clear water supply from an outside source with pressure at entrance point not less than pump shut-off head. Use back-sip-onage preventer. During operation, check packing glands for leakage. Allow slight leakage of seal water when pumps are running to keep packing cool and in good condition. Determine proper amount of leakage by experience. If leakage is excessive, tighten gland nuts evenly a few turns. Do not draw glands too tight. After adjusting packing glands, check to see that shaft turns freely by



(1) Shaft sleeve.
(2) Return guide bushing.
(3) Suction cover.
(4) Ball bearing.
(5) Thrust plate.
(6) Water-seal piping.
(7) Set collar.
(8) Spacer sleeve.
(9) Casing.
(10) Balancing disk.
(11) Runner.
(12) Return guide.
(13) Wearing ring.
(14) Shaft.
(15) Shaft sleeve.
(16) Water-seal ring.
(17) Packing.
(18) Glands.
(19) Oil-hole covers.
(20) Bearing housing.
(21) Babbitted shell.
(22) Oiling ring.
(23) Bearing housing.
(24) Pump half coupling.

Figure 40. Two-stage centrifugal pump, HYC type.

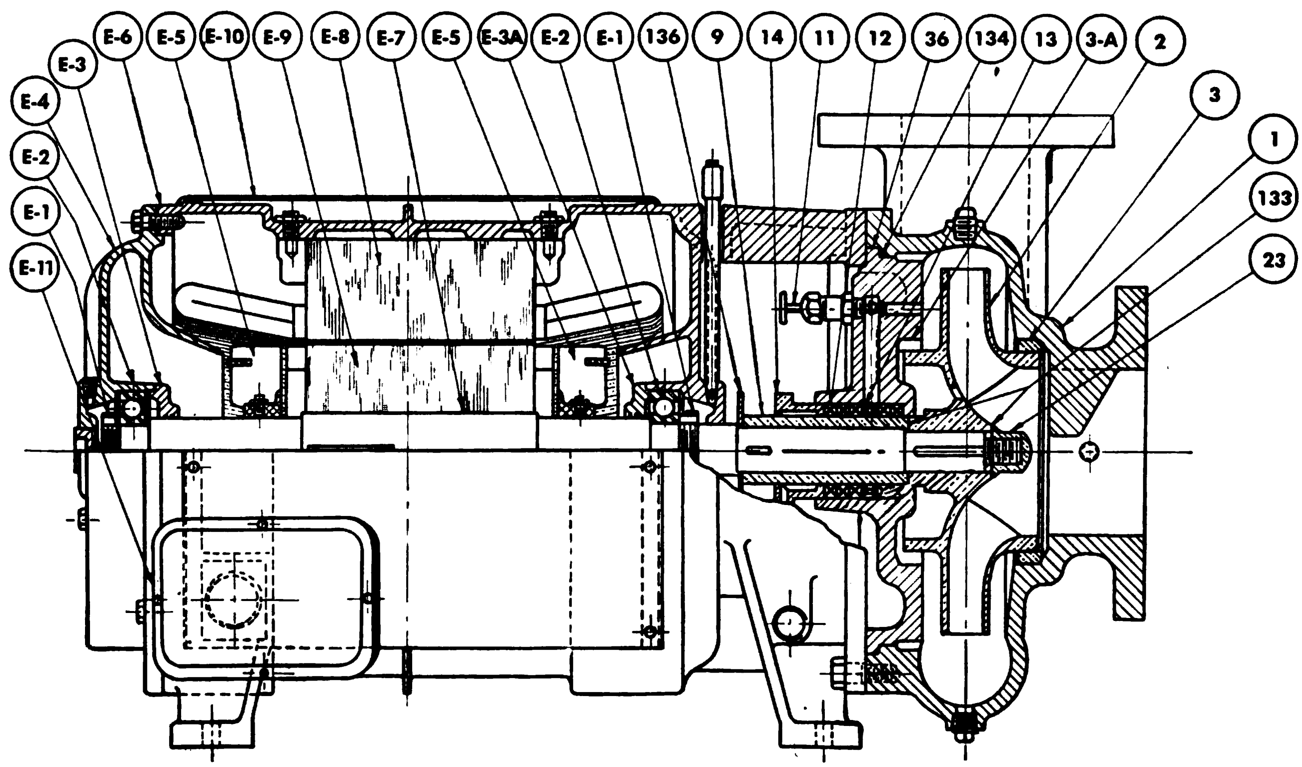
DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	
						hand. If serious leakage continues, renew packing, shaft, or shaft sleeve. (See also *a* (2) above.)
2						*c.* **Check Grease-sealed Packing Glands.** If grease is used in packing gland as a water seal, maintain constant grease pressure on packing during operation. When a spring-loaded grease cup is used, keep it loaded with WP grease. Check to see that grease is being forced through packing at rate of about 1 ounce per day.
	7					*d.* **Alternate Operation of Two or More Pumps.** If two or more pumps of the same size are present, alternate them to equalize wear, keep motor windings dry, and distribute lubricant properly.
	8					*e.* **Inspect Condition of Pump Assembly.** (1) Check float controls to make sure they respond to rising water level in clear well. Use light oil on mechanical



① Handhole cover.
② Casing.
③ Front side plate.
④ Open runner.
⑤ Rear side plate.
⑥ Stuffing-box bearing.
⑦ Packing.
⑧ Shaft sleeve.
⑨ Gland.
⑩ Shaft-sleeve nut.
⑪ Roller-bearing housing cap.
⑫ Grease cup.
⑬ Roller bearing.
⑭ Roller-bearing housing.
⑮ Bearing cap.
⑯ Shaft.
⑰ Roller-bearing housing cap.
⑱ Pump half coupling.
⑲ Lower-half bearing housing.
⑳ Adjusting shims.

Figure 41. Open-impeller centrifugal pump.

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	
						movements. See that unit starts when float switch makes contact and that pump empties clear well or reservoir at normal rate.
†						(2) Check motor condition, following maintenance procedure in paragraph 16.
						(3) Service stand-by pump. Run stand-by pump assembly at least weekly, long enough to obtain normal motor temperature.
	.9					*f.* **Check Packing-gland Assembly.** The packing-gland assembly is probably the most abused and troublesome part of a pumping unit. Maintenance suggestions that follow will help keep the assembly in good working condition. If stuffing box leaks excessively when gland is pulled up with mild pressure, remove packing and inspect shaft sleeve. If shaft sleeve is grooved or scored, replace it. Packing will not hold in a stuffing box with a roughened shaft or



(E1) Locknuts.
(E2) Ball bearings.
(E3) Cast-iron bearing cap (outer end).
(E3A) Cast-iron bearing cap (pump end).
(E4) Cast-iron end housing.
(E5) Fan.
(E6) Cast-iron yoke.
(E7) Shaft.
(E8) Wound stator.
(E9) Rotor.
(E10) Sheet-metal cover.
(E11) Sheet-steel conduit box.

(1) Casing.
(2) Inclosed runner.
(3) Wearing rings.
(3A) Wearing rings.
(9) Shaft sleeve.
(11) Water-seal valve.
(12) Set packing.
(13) Water-seal ring.
(14) Split gland.
(23) Runner retaining nut.
(36) Rear cover.
(133) Fiber gaskets.
(136) Water slinger.

Figure 42. Single-suction close-coupled centrifugal pump.

DAILY WEEKLY MONTHLY QUARTERLY SEMIANNUALLY ANNUALLY

shaft sleeve. Do not use rings when replacing packing. Dip each strip in heavy oil and graphite and tamp it in place before inserting the next. Stagger joints. Do not use a continuous helix or string of packing which either wraps around and scores shaft sleeve or is thrown against outer wall of stuffing box, allowing grit to leak through the packing and score shaft. In replacing gland, see that followers enter packing box at least ⅛ inch to prevent rocking at glands. Followers must not jam or touch the shaft. Type of packing used is less important than proper installation. Be sure lantern ring is positioned properly. If grease sealing is used, fill lantern ring with grease before remaining rings of packing are put in place.

25 *g.* **Inspect and Lubricate Bearings.** Unless otherwise specified for a particular pump model, drain lubricant, washing out oil wells and bearings with kerosene. With sleeve bearings, check that oil rings are free to turn with shaft. Repair or replace if defective. Refill with proper lubricant for sleeve, ball, roller, or Kingsbury bearings (see par. 7 and table VI). Measure bearings for wear, replacing if necessary. Generally allow 0.002 inch of clearance plus 0.001 inch for each inch or fraction of an inch of shaft-journal diameter.

26 *h.* **Check Operating Temperature of Bearings.** Check bearing temperature with thermometer, not by hand. If antifriction bearings are running hot, check for *too much* lubricant and remove excess. If sleeve bearings run hot, check for *lack* of lubricant. If proper lubrication does not correct condition, disassemble and inspect bearing. Check alignment of pump and motor if high temperature continue.

3 *i.* **Check Hand-oiler Settings.** If a hand oiler is used to oil shaft bearings, check setting daily as follows:

(1) For pumps operating once a month to 2 times a day, running time not over 5 minutes, 1 drop every 15 minutes.

(2) For pumps operating 3 to 12 times a day, running time not over 5 minutes, 1 drop every 4 minutes.

(3) For pumps operating up to 50 times a day, running time over 5 minutes, 1 drop every 2 minutes.

(4) For pumps operating more than 50 times a day, 2 to 4 drops per minute.

4 *j.* **Check Operation of Solenoid Oiler.** If solenoid oiler is used, see that solenoid leads are connected so solenoid is energized as soon as switch is closed, raising needle valve and allowing oiler to function. If no oil flows from lubricator after current is turned on, inspect needle valve for clogged opening. Set oiler at 2 to 4 drops per minute and check daily. Use OE 10 or NS 3050 in oilers.

27 *k.* **Lubricate Ball Thrust Bearing.** Lubricate ball thrust bearing with BR grease, placed in grease cup in bottom of motor base. If pump operates oftener than 50 times a day, change grease quarterly; otherwise change annually.

18 (1) **Service Grease Cups.** Put fresh BR grease in grease cup. Do not try to keep grease from coming out around seal at ball-bearing collar, because bearing housing is designed to relieve excess grease and prevent packing the ball bearing and overheating.

Caution: Do not run pump dry.

19 (2) **Service and Grease Bearings.** Proper lubrication of ball bearings in pumps is vitally important. Determine frequency of lubrication and cleaning to

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DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

suit equipment and service conditions. Lubricate with BR grease. Overheated bearings generally indicate too much grease rather than too little. Inspect overheated bearings carefully before adding grease.

28 *l.* **Flush Bearing Housing.** Open bearing housing, flush with clean kerosene and apply clean grease. Keep housing immaculately clean, and use only clean grease to lubricate bearings. Never lubricate bearings with used grease. Foreign solids or liquids in housing can quickly ruin bearings.

5 *m.* **Check Lubricating Oil Level in Ball-bearing Types.** Lubricate pump by keeping level of bearing-housing oil well just below overflow point of filling cup or oil plug. Use NS 3050 and check level daily. When adding oil, remove oil-vent plug in top of bearing housing.

Caution: Do not put oil in housing while pump shaft is rotating because rotary action of ball bearing picks up and retains oil which drains down when unit comes to rest, resulting in overflow of oil around shaft or out of oil cup.

30 *n.* **Lubricate Universal Joint Couplings.** Lubricate universal joint bearings and slip splines with BR grease added through Zerk or Alemite fittings. Annual greasing may be sufficient.

10 *o.* **Lubricate Bearings on Inclosed-shaft Type.** Before operating pump, fill thrust-bearing oil cup with NS 3080; refill weekly or oftener if necessary.

20 *p.* **Lubricate Guide Bearings.** On standard units, add BR grease through Zerk or Alemite fittings on floor plate under motor pedestal. On nonstandard units, follow manufacturer's recommendations.

21 *q.* **Lubricate Ball Bearings on Open-Shaft Type O.** Lubricate the two ball bearings separately through Zerk or Alemite fittings on bearing housing, or through extension grease lines. Lubricate pump bearing. Use BR grease.

11 *r.* **Check V-Belt Drive.** When V-belt drives are used, see that sheaves are in perfect alignment because slight variations cause excessive wear and shorten life of belt. For further information, see paragraph 18.

12 *s.* **Check Belt-Driven Units.** Maintain adjustments and alignment. Replace worn belts. (See also par. 18.)

31 *t.* **Check Alignment of Pump and Motor.** If misalignment of pump and motor recurs frequently, inspect entire piping system. Unbolt piping at suction and discharge nozzles to see if it springs away indicating strain on casing. Check all piping supports for soundness and effective support of load. Shim units as needed. For further information, see paragraphs 24 and 45*a*(5).

Vertical pumps usually have flexible shafting, permitting slight angular misalignment. However, when solid shafting is used, alignment must be exact. If beams carrying intermediate bearings are not heavy enough or distort because of contraction or expansion, replace beams and carefully realign intermediate bearing.

32 *u.* **Inspect and Service Pumps.** Remove rotating element and inspect thoroughly for wear. Order replacement parts where necessary.

(1) Remove any deposit or scaling. Clean out water-seal piping.

(2) Determine pump capacity by volumetric calibration method such as pumping into an empty tank or time of draining clear well. (See also *a*(2) above.)

(3) Make efficiency test of pump (see par. 39, and *a*(2) and (5) above).

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	
						(4) Inspect foot valves. Examine check valves with extreme care (see par. 103).
						(5) Examine wearing rings. To protect wearing rings and casing, never allow pump to run dry through lack of proper priming when starting, or through loss of suction when operating. When seriously worn, replace rings to improve pump efficiency. Check wearing-ring clearances, which generally should be no more than 0.003 inch per inch diameter of wearing ring.
					*	*v.* **Drain Pump When Shutting Down.** When shutting down pump for long periods, open motor disconnect switch, shut all valves on suction, discharge, water-seal, and priming lines, and drain pump completely by removing vent and drain plugs until water has run out. This protects pump against corrosion,

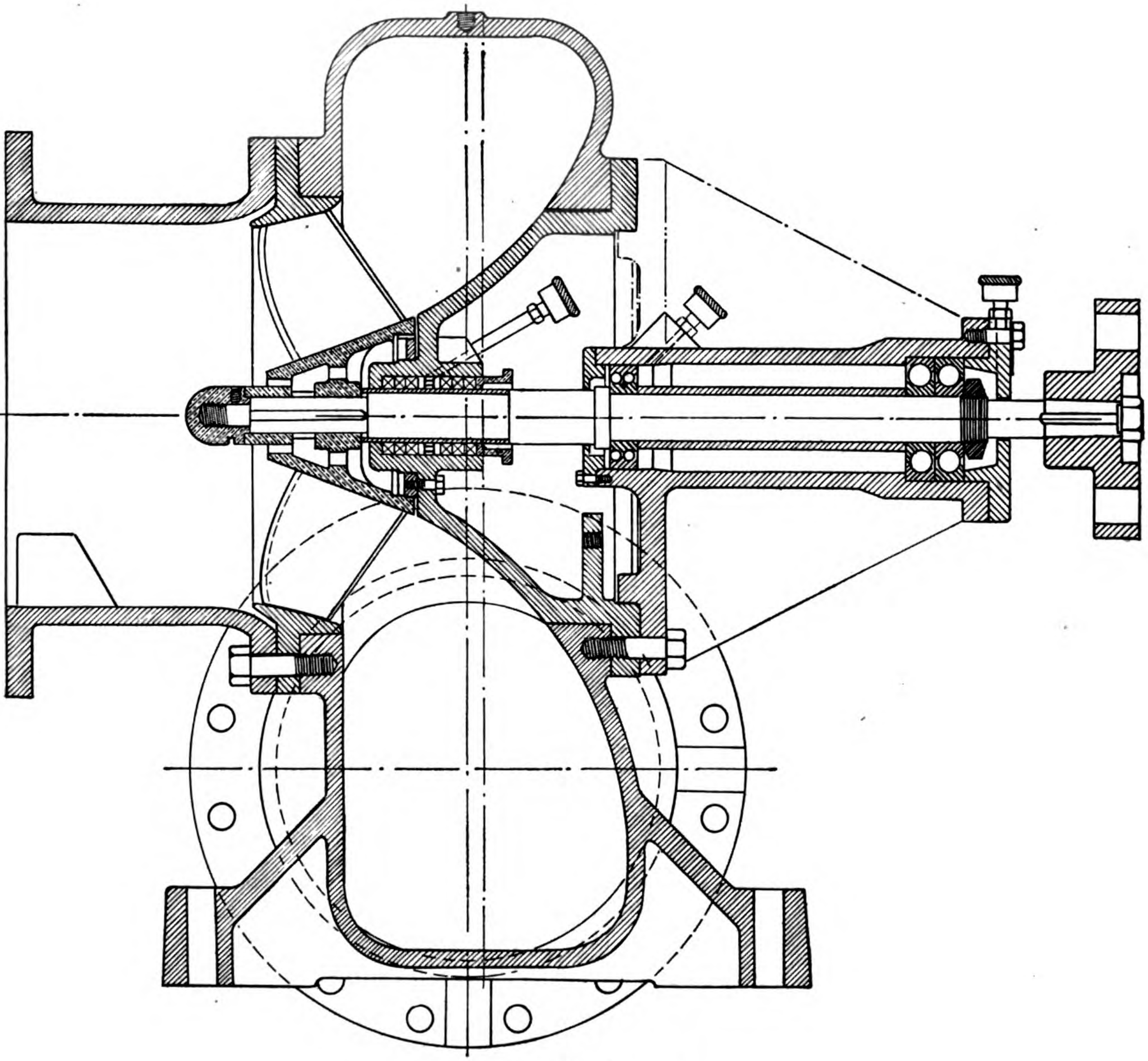


Figure 43. Mix-flow pump.

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY

sedimentation, and freezing. Inspect pump and bearings thoroughly and complete necessary servicing during inactive period. Drain bearing housing and replenish with fresh oil or purge of old grease.

46. Mixed-flow Type Pumps

Mixed-flow pumps (fig. 43). transmit pressure energy to water partially by screw action and partially by centrifugal force. Water discharges from the impeller in a path inclined to the shaft's axis and can discharge into a volute case or into an expanding chamber parallel to the shaft.

† **Service pump,** following applicable procedures in paragraph 45. These pumps develop cavitation oftener than true centrifugal pumps. If pitting is noted on impeller or pump passages, consult post engineer. Mixed-flow pumps should have negative heads within manufacturer's recommendations and recommendations in Standards of the Hydraulic Institute, 90 West Street, New York City. For mixed-flow pumps with open impellers, limit clearance between vanes and guide ring to those prescribed by manufacturer. In general, radial clearance of no more than $\frac{1}{32}$ inch is permissible.

47. Axial-flow Type Pumps

Axial-flow pumps (fig. 44) transmit pressure energy to water entirely by screw action. Water discharges from the impeller parallel to the axis of the pump.

† **Overhaul and inspect pump,** servicing applicable items covered in paragraph 45. Axial-flow pumps rarely have wearing rings, and need no wearing ring maintenance. Axial-flow pumps normally need submergence or positive-suction heads to prevent cavitation. If cavitation is noted, investigate suction conditions. Follow recommendations of manufacturer and recommendations in Standards of the Hydraulic Institute, 90 West Street, New York City.

48. Turbine Type Pumps

In turbine type pumps (fig. 45) the shape of the liquid channel keeps liquid constantly recirculating through recurring vanes of the impeller as it travels from suction to discharge outlet with an ever-increasing pressure. Direction of flow is through vanes to rim of impeller and into liquid channel. For comparison of turbine type with centrifugal type see figure 46.

† *a.* **Overhaul and inspect.** Service applicable items discussed in paragraph 45. With pump assembled, check clearance of impeller between liners and check movement of shaft endways. Because most pumps of this type have an adjustment for centering the impeller, adjust clearance equally on both sides of impeller. See manufacturer's instructions. If clearance is not 0.010 to 0.012 inch, replace impeller and liners.

33 *b.* **Paint.** Coat interior iron of pump with suitable underwater paint or protective material.

49. Scru-peller Sludge Type Pumps

13 *a.* **Service and Lubricate Bearing and Filters.** Lubricate sludge pump with OE 30 or NS 3080 added through the two oil cups on bearing housings. Oil passes through wick filters before reaching bearings.

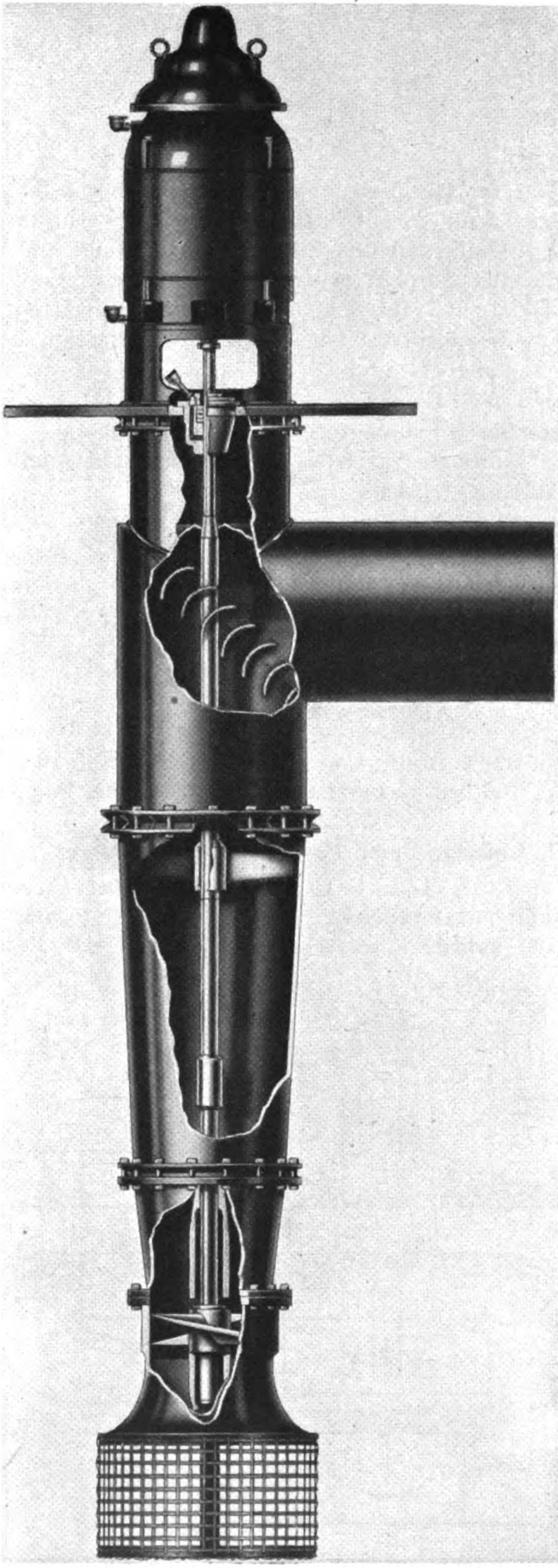


Figure 44. Vertical axial-flow pump.

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	
					34	(1) Replace filters, removing outer bearing-retaining plate and outer thrust plate. Pull out old wicking and replace with new lengths.
					35	(2) Drain and flush out bearing housings and refill with new oil. Do not oil while shaft is revolving because bearings pick up and retain oil which sinks when pump is at rest, raising oil level too high. Keep oil level below low side of shaft. Check for overlubrication, apparent when oil overflows around shaft.
6						*b.* **Check Grease Pressure in Seals.** When grease seals are substituted for water seals, follow procedure of paragraph 45.
†						*c.* **Lubricate Varidrive.** Lubricate varidrive unit according to instructions in paragraph 21.
	14					*d.* **Check Packing Glands.** Watch glands for leakage. When water seals are used, allow about 60 drops leakage per minute from packing boxes when pump is running. This is needed to keep packing cool and in good condition. If serious leakage is noted, tighten the two gland nuts evenly, taking only a few turns; do not draw glands too tight. After adjusting packing glands, turn shaft by hand to be sure it turns freely. (See also par. 45(*a*)(5).)
		22				*e.* **Clean Float Mechanism.** When automatic priming equipment is used on sludge installations, be particularly careful to keep mechanism clean.
†						*f.* **Check Motor Condition.** See paragraph 16.
†						*g.* **Perform General Pump Maintenance.** See paragraph 45*d*, *h*, *i*, *l*, *t*, and *u*.

50. Chicago Sump Pumps and Bilge Pumps

a. Types L–1, L–1B, and L–1C Sump Pumps and L–1D Bilge Pumps. Maintenance procedures below also apply to most other types of sump pumps.

(1) **Lubricate bearings.** Types L–1, L–1B, L–1C, and L–1D Chicago sump

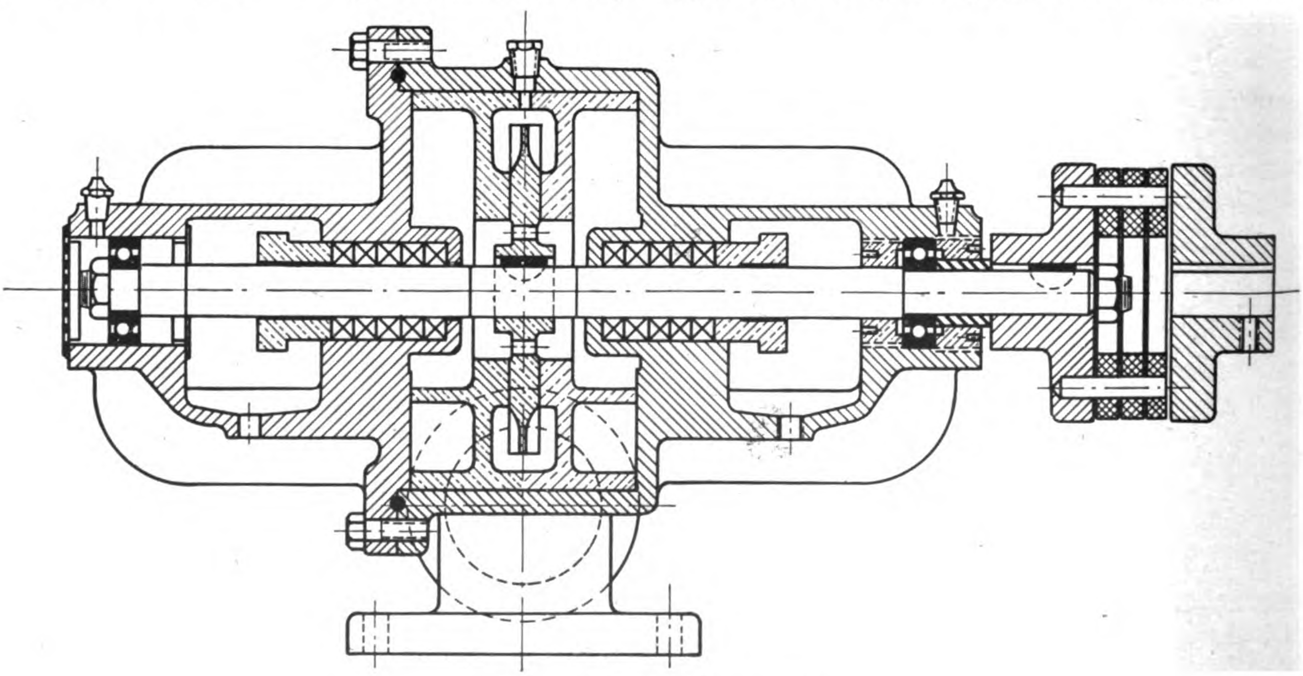


Figure 45. Turbine type pump.

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	
						pumps and bilge pumps are lubricated by two oil cups, one serving the guide bearings and the other, the thrust bearing.
	15					(*a*) Fill guide-bearing cup with OE 30 or NS 3080.
	16					(*b*) Fill thrust-bearing cup with OE 30 or NS 3080. Keep oil level about ⅛ inch below top of cup.
				29		(*c*) Drain the thrust-bearing well by removing drain plug in oil line just below oil cup. Flush with kerosene or OE 10 and refill with new lubricant.
		23				(2) **Inspect and clean basin.** Run pump until basin is drained and inspect basin for accumulated sludge or solid material. Check the strainer for clogging. Clean basin thoroughly, removing pump from basin if necessary.
†						(3) **Perform general pump maintenance.** See paragraph 45*e*, *f*, *h*, *l*, *t*, and *u*.
	17					*b*. TYPES LG–2 AND LGL–2 BILGE PUMPS. (1) **Lubricate bearings.** Type LG–2 and LGL–2 bilge pumps have a lifetime charge of lubricant for intermediate bearings reservoired in pump-leg sections. The lowest or discharge-casing bearing is water lubricated and designed for underwater service and requires no lubrication. The thrust bearing and upper bronze guide bearing are lubricated by a grease cup on the motor-pedestal floor. This cup is grease-filled at factory. Give cup a half turn before starting pump. Keep cup filled with WB 2 grease and turn cup down two or three turns every week.
		24				(2) **Clean basin.** Run pump until basin is drained, break electric circuit, disconnect discharge pipe at union, and pull unit out of basin. If unit is floor-plate type, remove anchor bolts. Clean out sludge or foreign matter accumulated in basin and on strainer before returning pump to service.
†						(3) **Perform general pump maintenance.** See paragraph 45*e*, *f*, *g*, *h*, *l*, *t*, and *u*

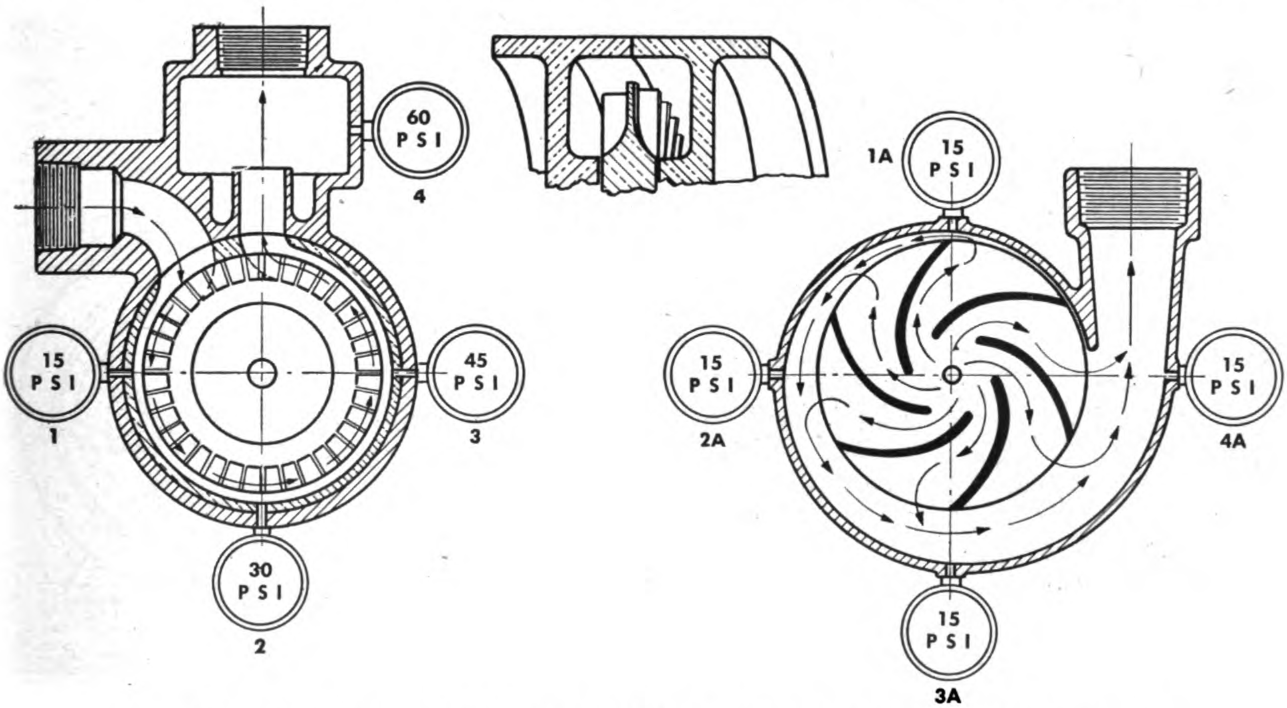
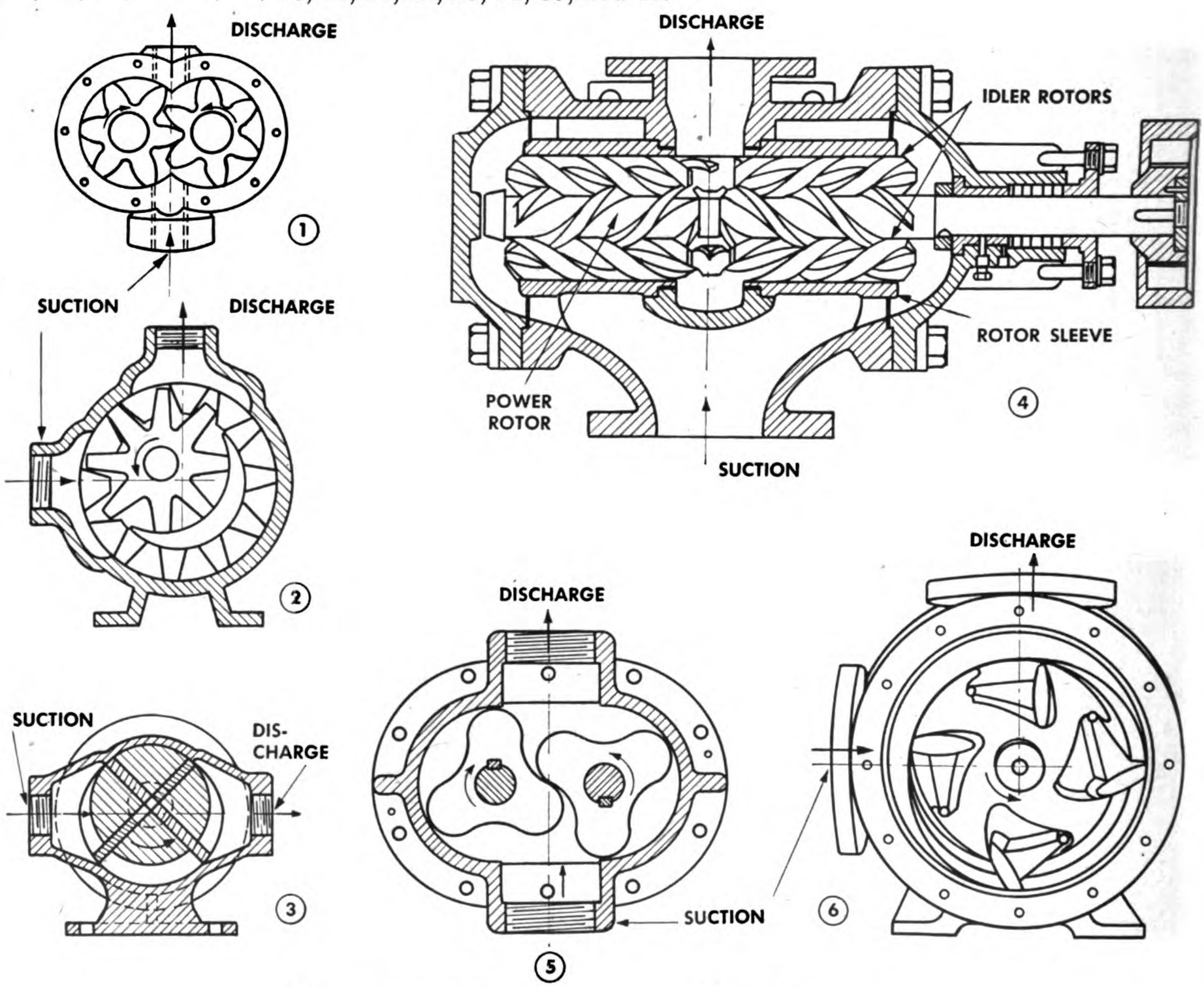


Figure 40. Flow in turbine type (left) and centrifugal type pump (right). (Note increase in pressure in turbine type pump as liquid approaches discharge outlet.)

SECTION XII
ROTARY PUMPS

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	
						51. General The term rotary pump normally refers only to rotary displacement pumps and not other rotating types such as centrifugal and screw pumps.
†						*a.* **Perform General Pump Maintenance.** Because of the many types of rotary pumps (fig. 47), detailed preventive maintenance cannot be covered here; obtain maintenance schedules from manufacturers' instructions. Include on the field card procedures for applicable items covered in paragraph 45.
					1	*b.* **Overhaul and Inspect.** Disassemble pump and clean thoroughly inside and out. If interior is subject to rust, paint with a suitable underwater paint or effective protective coating. Paint exterior. Check clearance of moving parts; for proper clearances, consult manufacturer's instructions. Check packing assembly and repack. (See par. 40.)
†						Check bearing clearances, alignment, and applicable items in paragraphs 16, 18, 21, 22, 23, 24, 39, and 40.



① Spur-gear pump.
② Internal-gear pump.
③ Sliding-vane pump.
④ Screw pump.
⑤ Three-lobe pump.
⑥ Swinging-vane pump.

Figure 47. Types of rotary pumps.

DAILY WEEKLY MONTHLY QUARTERLY SEMIANNUALLY ANNUALLY

SECTION XIII
RECIPROCATING PUMPS

52. General

Reciprocating pumps are of three general types, plunger, piston, and diaphragm. A piston pump operates in a cylinder much as pistons do in steam cylinders. A plunger pump has a displacement plunger which moves in and out of chamber much larger than the plunger. A diaphragm pump consists of a diaphragm, generally of rubber, with one side in contact with the fluid being pumped, the diaphragm being moved reciprocally by the driver to displace liquid. Inlet and outlet check valves in the system enable all three types to pump liquid in one direction.

† *a.* **Check Drives.** Drives for these pumps are mechanisms producing reciprocating motion, usually powered by a rotating driver such as an electric motor. For scheduled preventive maintenance, see manufacturer's instructions and paragraphs 16, 18, 19, 24, and 25.

10 *b.* **Check Slippage.** Determine quantity of water delivered per stroke. Compute or obtain from manufacturer volumetric displacement of pump and determine percent delivery per stroke.

(1) *Volumetric displacement.* Volumetric displacement is the piston or plunger area multiplied by length of stroke with proper allowance made for double-action pumps.

(2) *Percent delivery.* The delivery per stroke should be not less than 95 percent of volumetric displacement, except for diaphragm and very small piston and plunger pumps. If delivery is less than 90 percent, check valves, piston, and packing for leakage. Make necessary replacements.

11 *c.* **Inspect Pump.** Dismantle and thoroughly inspect pump. Remove and examine all valves, valve seats, and valve springs. Remove all old packing. Examine plunger or rod for scoring or grooving. Repack. (See par. 40.) Check alignment. (See par. 24.) Clean interior and exterior of pump. Paint interior iron with suitable underwater paint or protective coating. Paint exterior. On diaphragm pumps, clean and carefully examine diaphragm for defects or leaks. Inspect drive mechanism thoroughly. Consult manufacturer's instructions and Section IV.

53. Sludge Pumps

The following general provisions apply to reciprocating sludge pumps (fig. 48) discussed in this section as well as others in use at posts.

5 *a.* **Check Shear-pin Adjustment.** Set eccentric by placing shear pin (a common 8d or 10d nail) through proper hole in eccentric flanges to give required stroke. Tighten the two ⅝- or ⅞-inch hexagonal nuts on eccentric flanges just enough to take spring out of lockwashers. (See also par. 25.)

* *b.* **Check Cause of Shear-pin Failure.** Failures are caused by one of the following: a solid object lodged under the piston; a clogged discharge line; or a stuck or wedged valve. When shear pin fails, eccentric moves toward neutral position, preventing damage to pump. Remove cause of failure and insert new shear pin.

6 *c.* **Check Packing Adjustment.** Give special attention to packing adjustment because packing which is too tight reduces the unit's efficiency and scores piston walls. Keep packing just tight enough at all times to keep sludge from

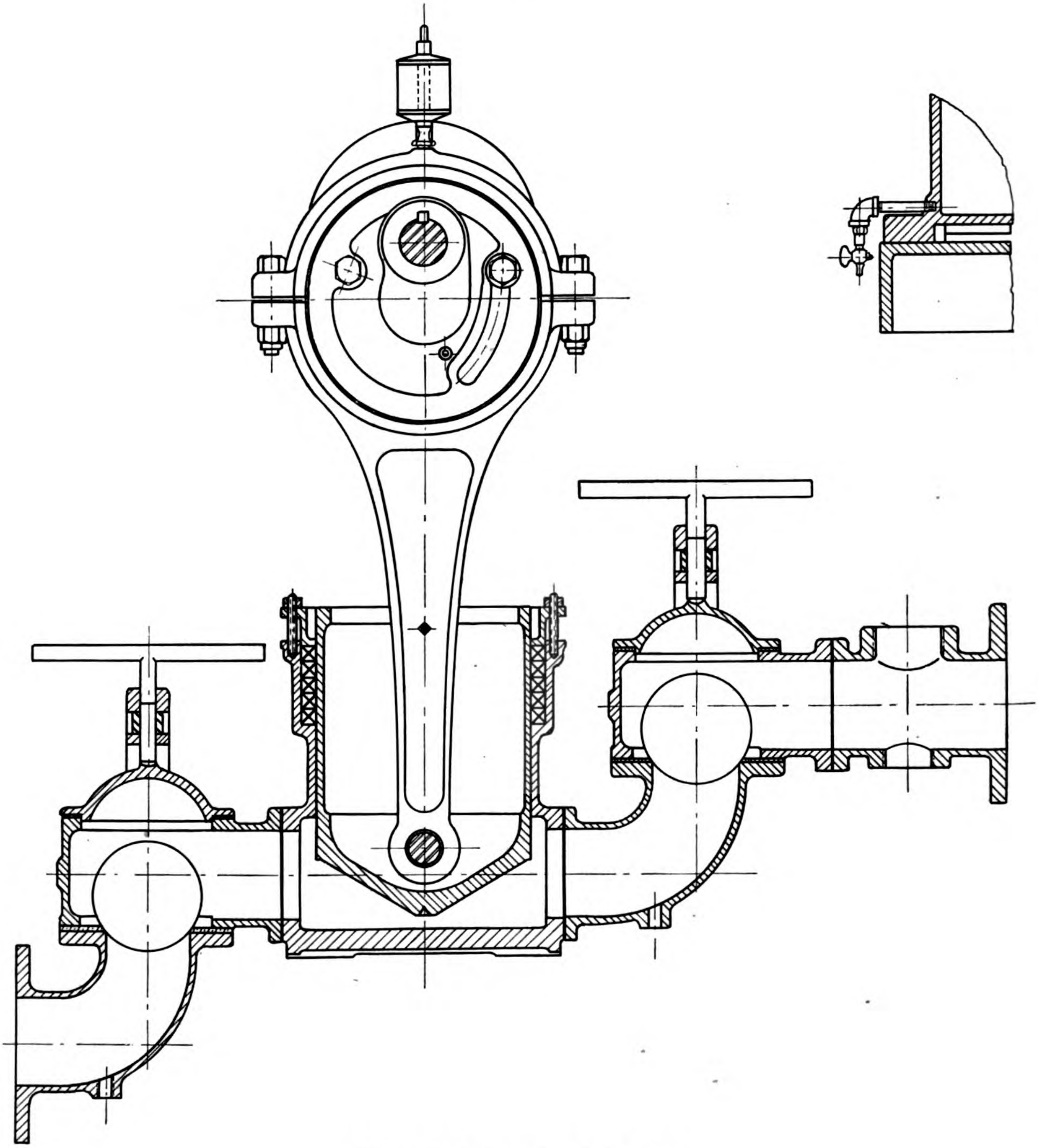


Figure 48. Reciprocating sludge pump.

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	
						leaking through gland. Before pump is operated, especially after it has been standing idle for a time, loosen all nuts on packing gland.
1						*d.* **Check Lubrication of Packing.** A sight-feed oil cup is usually provided for lubrication between plunger and stuffing box. Keep cup filled with NS 4065 oil. One filling should be enough for about 10 hours of operation. In addition, squirt oil frequently around the plunger. Run the pump with sludge line closed and valve covers open for a few minutes to break packing in. Turn down gland nuts no more than necessary to keep sludge from getting past packing. Tighten all packing nuts uniformly.
					*	*e.* **Renew Packing.** When no take-up is left on packing gland bolts, replace packing. Remove old packing and thoroughly clean cylinder and piston walls. Place new packing in cylinder and tamp each ring into place. Make sure joints on packing rings are staggered. Adjust packing as explained above. When chevron type packing is used, see that nuts holding gland are only finger-tight because excessive pressure quickly ruins packing and scores plunger.
			8			*f.* **Check Ball Valves.** Replace valve balls which are so worn that they are small enough to jam into guides in valve chamber. This will not occur until original diameter of ball has been decreased ½ inch. Check valve chamber gaskets. They are usually designed to act as a safety valve and blow out when excessive pressure is developed in the pump. Keep additional gaskets on hand for replacement.
					12	*g.* **Check Eccentric Adjustment.** Remove brass shims from eccentric strap to take up in babbitt bearing. After removing shims, operate pump for at least 1 hour and check to see that eccentric is not running hot.
2						*h.* **Note Unusual Noises.** Check piping arrangement and head conditions for noticeable water hammer when pump is operating. Water hammer is pronounced when pumping water or very thin sludge and decreases or disappears when pumping heavy sludge. Eliminate noise by opening the ¼-inch petcock on pump body slightly. This draws in a slight amount of air, keeping discharge air chamber full at all times. Some installations require air chambers approximately 6 inches in diameter and 36 inches high on the suction side.
3						*i.* **Check Control-valve Positions.** A plunger pump may de damaged if operated against closed valves in the pipe line, especially in discharge line. Make all changes in valve settings with pump shut down because a pump may be installed to pump from two sources or deliver to separate tanks at different times. This eliminates danger of all suction-line valves or all discharge-line valves being closed for a few seconds causing pump breakage.
†						*j.* **Check Gear Motor.** Follow closely factory instructions attached to gear motor. See also paragraph 16.
†						*k.* **Service Electric Motor.** Follow procedure of paragraph 16.
		7				*l.* **Check Gear Transmission.** (1) **Keep gear transmission filled to proper level.** Use NS 6135 in summer and NS 3080 in winter.
			9			(2) **Change oil.** Change quarterly or more often if necessary to prevent sludging. Open drain monthly to eliminate accumulated moisture.
4						*m.* **Lubricate Bearings and Gear Transmission.** All bearings are fitted with Alemite buttonhead industrial type fittings. Grease with pressure gun at least once each shift, and more often if pump runs steadily for long periods. Use CG 1 grease.

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

SECTION XIV
PUMP AUXILIARIES

54. Priming Systems

Most priming systems have typical mechanisms whose maintenance is covered in other sections of this manual. The sanitary engineer or works supervisor should study those sections and manufacturers' data in preparing field cards.

1 *a*. **Check Automatic Type Systems.** Observe general performance.

2 *b*. **Inspect DeLaval System.** Check ejector, electrodes, solenoids, relays, and check valves. (See fig. 49.)

3 *c*. **Check Vacuum-Pump Type Systems.** Check air compressors, pressure controls, vacuum-relief valves and float valves on vacuum-pump type systems. Inspect valve seats, diaphragms, contacts, floats, and float mechanisms (fig. 50).

† *d*. **Inspect Plunger-Pump Type Systems.** Follow services outlined in section XIII.

4 *e*. **Service Self-Priming Pumps.** Overhaul and inspect. Check clearances, wear, and defects due to use, and make necessary replacements.

55. Automatic Controls

Control apparatus for starting and stopping pumps is activated by various methods such as pressure, floats and cables, and the electrical conductivity of water. The equipment not only includes various types of electrical controls such as solenoids, contactors, relays, and alarms but also may include air lines, compressed air equipment, pressure regulators, and float valves. Such control systems are often made up of various combinations of ordinary and special devices.

* *a*. **Maintenance.** Determine preventive maintenance operations for this equipment after a thorough study of manufacturer's instructions and this manual.

1 *b*. **Check Operation.** Observe pressures and water levels in relation to control settings. Observe equipment operating through complete cycle of operation. If apparatus includes a pressure tank with air above the water for reserve supply, check water level in tank to be sure system is not waterlogged.

5 *c*. **Overhaul and Test.** Clean all parts thoroughly. Test each unit for proper functioning. Disassemble and check interior mechanisms of all valves, float controls and diaphragm assemblies. Check packing and stuffing boxes on valves, pivots, etc. Test and adjust apparatus to function properly as a unit. Apply hydrostatic test to all tanks at 50 percent more than their operating pressure. (See sec. XXIII.)

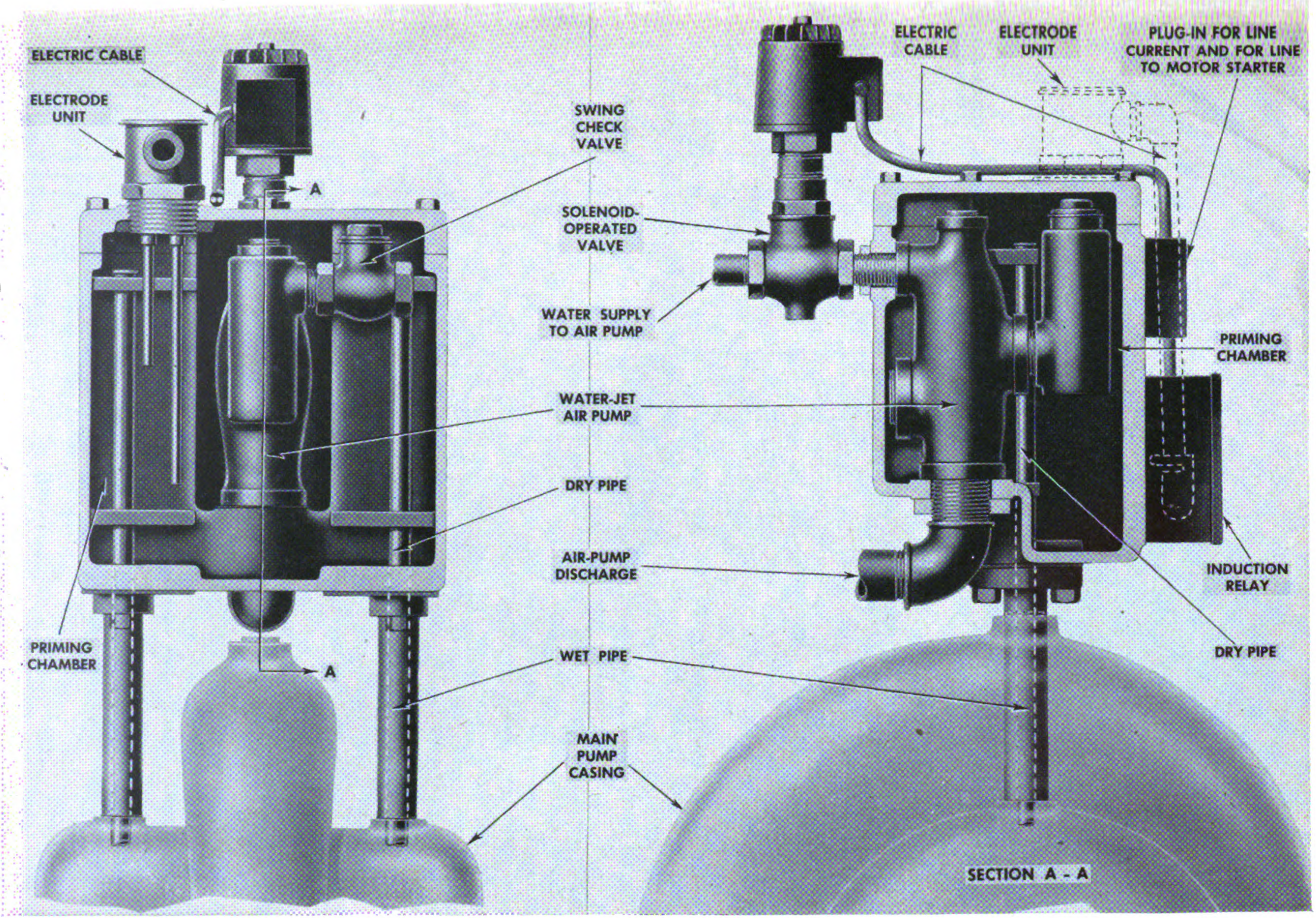


Figure 49. DeLaval submerged suction priming system with ejector, electrodes, solenoid, and relay.

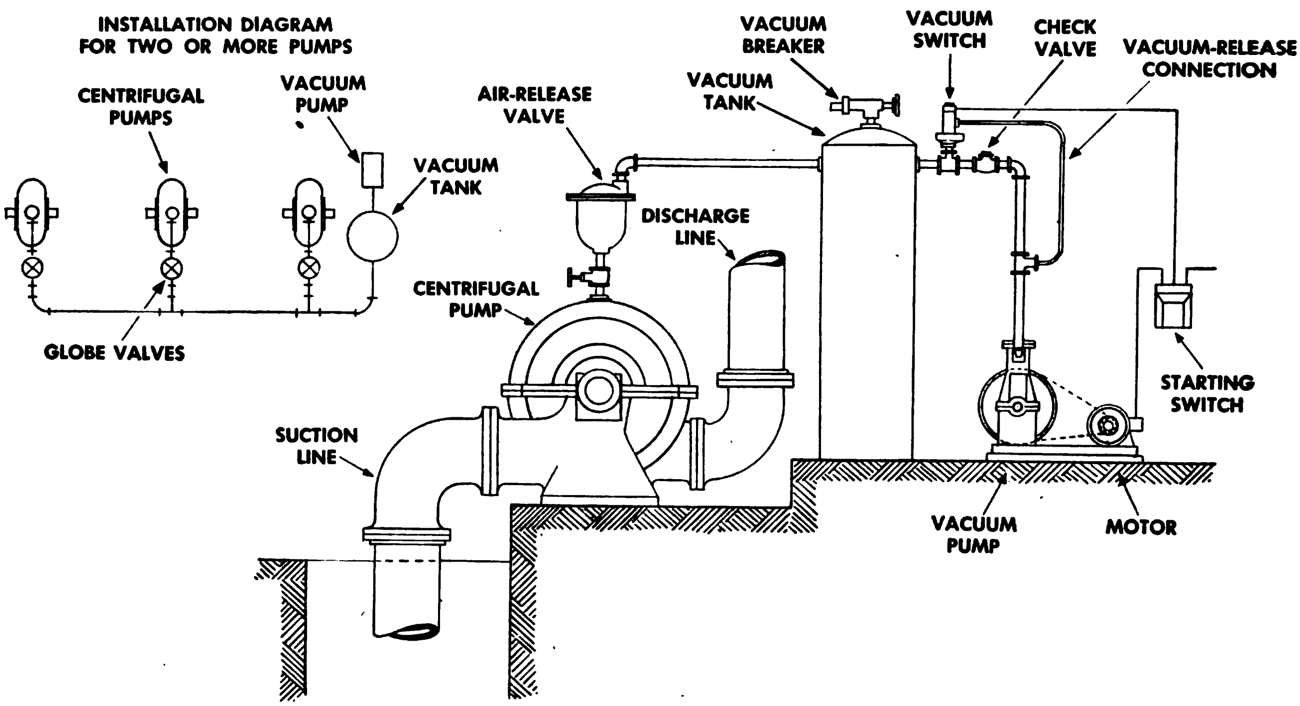


Figure 50. Typical installation lay-out of automatic vacuum primer system.

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

SECTION XV
BASINS

56. Settling Basins, Revolving Type Concentrators

Some preventive maintenance services and operation are common to many basins regardless of their function. In preparing field cards, refer to section IV and manufacturers' instructions to make sure no necessary service is left out. The following scheduled services apply to several types of revolving and conveyor types of mechanical sludge-concentration apparatus. Select applicable items and supplement where necessary.

a. DORRCO (REVOLVING TYPE A). Recommended time intervals between lubrications are based on continuous operation. If machine is operated intermittently, increase interval to suit actual operating time. If machine is to be idle long, take necessary precautions to prevent damage. If practicable, operate mechanism periodically for a few minutes to keep working parts, particularly the balls, races, and gears, thoroughly coated with lubricant. If machine is outdoors or in cold temperatures, change grade of lubricant with the seasons, particularly the heavy worm-gear oils which do not flow readily at below-freezing temperatures.

8 (1) **Inspect and lubricate reducers and oil baths.** Inspect speed reducers and oil baths to see that the oil level is clean, of good body, and at proper level. Drain small amount of oil from bottom of gear casing and oil baths to eliminate water accumulated through leakage or condensation, and to check for grit, body and oiliness.

1 (*a*) **Lubricate drive head.** Lubricate counter shaft bearings through three Alemite buttonhead fittings; use CG 1 grease. When machine is operated continuously, lubricate bearings with a small amount of grease in each fitting. Avoid excessive lubrication to prevent grease from entering worm-gear housing and mixing with oil, producing a heavy oil which will not flow properly around ball bearings and worm gears. Excess grease may also enter the overload alarm box which should not be lubricated. Do not force too much grease into fitting next to sprocket because shaft seal may be forced out of place.

2 (*b*) **Lubricate worm gear and turntable bearing.** Check oil level. To add oil, remove worm-gear cover and fill slowly until oil comes from overflow elbow. The first few revolutions of machine lubricates ball race and balls thoroughly See that overflow elbow points downward.

26 Drain and refill with NS 3080 in winter and NS 6135 in summer.

14 (*c*) **Drain moisture from housing.** Open drain on gear housing and remove any water accumulation.

15 (2) **Lubricate roller chain.** (*a*) Use NS 3065 in summer and NS 2075 in winter if chain guard is totally inclosed and chain dips into oil bath. Add oil through inspection opening in side of chain guard. Open drain plug to drain off water accumulation.

16 (*b*) Use roller-chain lubricant or NS 6135 in summer and NS 3080 in winter if chain guard is semi-inclosed. With this type guard, chain cannot run in oil bath because the bottom is open.

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	
				27		(*c*) Flush and change oil.
					35	(3) **Inspect and service tank equipment.** Check all bolts and tighten nuts to maintain original alignments and adjustments.
	9					(*a*) Examine gears and all wearing parts for excessive wear. If the mechanism is stopped longer than 1 hour, bypass flow until machine is started. Keep machine and surroundings clean.
		17				(*b*) Service shear pins. (See par. 25.)
†						(*c*) Check motor condition. (See par. 16.)
				28		(*d*) Check couplings and alignment. (See par. 24.)
		18				(*e*) Flush and back-blow underflow line with high-pressure water or compressed air. Protect water connection against cross-connection hazards. See that sludge or foreign matter is not plugging discharge line.
3						*b*. DORR (TYPE W). (1) **Lubricate countershaft bearings.** The worm countershaft on Dorr type W basins runs in two Oilite bronze bushings of porous construction to absorb and retain oil. Add a few drops of OE 30 to oil cups over bushings to provide ample lubrication for shaft.
4						(2) **Lubricate gears and bearings.** Lubricate worm, worm gear, annular ball bearing, and thrust bearings by oil bath in housing. Measure oil-bath level by upstanding nipple on oil drain and overflow piping. Remove worm cover and overflow cup through access opening in walkway. Pour oil slowly into worm compartment until level reaches top of overflow pipe. The first few revolutions of machine lubricate ball race and balls thoroughly.
				29		Drain and refill with NS 6135 in summer and NS 3080 in winter.
		19				(3) **Lubricate roller chain.** Chain is lubricated by dipping into an oil bath in the oil- and dust-tight chain guard. Pour oil guard through inspection opening in top until oil is level with small pipe plug in side of housing. Avoid overfilling which may cause leakage. Use NS 3065 in summer and NS 2075 in winter.
			24			Open drain plug and drain off any water accumulation. Check oil level, and add oil if necessary.
		20				(4) **Lubricate gears and bearings.** Check lubrication of worm, worm gear, turntable bearing, shaft bushing, and ball thrust bearing, all lubricated by oil bath in housing. Check oil level by upstanding nipple on combination drain-and-overflow piping at side of worm chamber. Take out removable section of walkway to gain access to covered opening over the worm when oiling housing and inspecting gears. After removing worm cover and overflow cap, pour in oil slowly until it reaches top of overflow nipple. Replace the cap and run machine for 1 or 2 hours before checking oil level again. First few revolutions of gear coats balls and races thoroughly. Use suitable heavy oils such as NS 6135 in summer and NS 3080 in winter.
5						(*a*) Check oil level.
				30		(*b*) Drain and refill to proper level. Too high a level may cause leakage over the inner wall of the gear housing.
		21				*c*. DORR (TYPE SU). (1) **Check annular ball-bearing lubrication.** Oil level in ball-bearing housing is set by the overflow pipe under handhole cover. Remove pipe monthly for inspection. If oil is low, add oil through fill pipe until it is level with top of overflow pipe. Add oil slowly and allow time for it to work around ball race while machine is operating. A special pumping arrange-

Daily	Weekly	Monthly	Quarterly	Semiannually	Annually	
						ment, requiring no attention by operator, is built into turntable base casting to lubricate pinion and internal gear at point of contact. Use NS 3065 in summer and NS 2075 in winter.
				31		Drain oil, flush turntable with kerosene, and refill with fresh oil.
		22				(2) **Lubricate motor reducer.** Change oil in reducer under continuous operation, using OE 10 in winter and NS 3050 in summer.
		23				(3) **Grease turntable and drive case.** Apply grease with grease gun to Alemite fittings on turntable and chain drive case. Use WB 2 grease, at all temperatures.
					36	(4) **Check and adjust chain drive.** Remove top cover plate to examine chain. If chain is too slack, loosen nut and turn idler sprocket until chain is taut.
				32		*d.* LINK-BELT CIRCULINE (TYPES A AND B). (1) **Inspect entire equipment and service collector rings and pivot bearings.** Drain tank completely. Check for excessive wear or breakage in all working parts which are normally under the liquid surface. When tank is drained, inspect and service electric current collector rings and pivot bearings on center column. Lubricate current collector rings and fingers with vaseline or with CG 0 in winter and CG 1 in summer.
			25			(2) **Check oil level at center bearing.** Refill with NS 5190 or NS 6135 as required.
	10					(3) **Check oil level in reducer.** Use NS 3065 oil for herringbone and motorized reducers. On worm gears, use NS 3080 in winter up to 40° F. and NS 6135 above 40° F.
	11					(4) **Grease bearings and movable parts above water level.** Use BR.
	12					(5) **Grease gears and chain drives.** For roller chains use OE 30, NS 3080, or CW 2.
6						(6) **Check ice formation and lubricate collector chains.** Before starting collector equipment in extremely cold weather, make sure ice has not frozen tow chain to pocketed wheel. Remove guard and use a bar to free chain frozen in pockets. Use discarded crankcase oil on tow chain and chains operating from driving mechanism into water.
					37	*e.* CHAIN BELT (TOW-BRO TYPE). (1) **Change oil in reducer.** Change oil after first month of operation and semiannually thereafter.
	13					(2) **Check oil level in reducer.** If water condensation is present in oil, drain completely, flush out, and put in new oil. When reducer runs hot, check oil level because too much or too little oil may cause overheating. If reducers are taken out of service for a long period of time, fill them completely with oil to prevent oil seals from drying out. Use lubricants discussed in paragraph 7 and table VI.
						Note. Do not lubricate Eel slip type underwater bearings.
				33		*f.* YEOMAN'S SIMPLEX TYPE. (1) **Lubricate reduction gear.** Drain reduction-gear case completely and refill with fresh oil before operating. Keep filled to top of gauge pipe; measure oil level when equipment is not operating. Use NS 3080 for ordinary temperature and OE 30 for temperatures below 50° F.
				34		(2) **Fill grease cups and Alemite fittings.** Add 1 cup CG 1 grease in summer and CG 0 in winter.

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DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY

7 (3) **Lubricate roller thrust bearing.** Roller thrust bearing supports main driveshaft and scraper. Lubricate it through ¼-inch pipe connection with Alemite fitting on side of gear-reducer support housing. Keep bearing filled with BR grease.

38 *g.* **Drain Basin and Clean and Inspect Structure** (par. 11). To preserve iron shoes on wood flights, braze them with spots of Stellite.

39 (1) **Inspect waste valve.** Inspect valve face to insure proper seat. When closing waste-line valves, do not exert so great a pressure on rod that valve stems are bent. Seat the valve, back it off two turns, and then reseat it, being sure that valve faces are wedged together firmly.

40 (2) **Inspect inlet valve.** Determine that inlet valve is holding properly. Make necessary repairs.

* *h.* **Obey Overload Alarm.** (1) When overload alarm rings, do not keep equipment running. Find and remove source of trouble. Do not start equipment with load of sludge in tank. Do not tamper with overload alarm switch adjustments to keep the machine running under overloaded conditions.

(2) **Check for sludge overload.** If sludge overload is built up, open discharge line while machine is running to remove sludge. If overload is so heavy that heater coils in starter box cut out switch and stop machine, drain tank and sluice out sludge. If some foreign object drops into tank, stop machine and fish it out, if necessary cutting off influent to prevent too great an accumulation of sludge. If object cannot be removed with tank filled, drain tank and remove object before resuming operation.

57. Settling Basins, Conveyor Type Concentrators

2 *a.* **American Well Works Type.** (1) **Check reducer.** See that oil is level with petcock installed on side of unit. This must be done when unit is not operating.

13 Change oil for summer and winter lubrication. See paragraph 7 and table VI for proper lubricants.

3 (2) **Grease sprocket assembly.** Grease insert on drive sprockets of output-reducer shaft with WB 2 grease to prevent sprockets from binding to shaft. This would cause loss of protection of shear pin connecting sprocket to coupling or to jaw clutch in dual-drive units.

9 (3) **Oil dual-drive jaw clutches and bearing.** Disengage jaw clutch from jaw coupling to put one unit out of service. To do this, reverse the unit momentarily to relieve stress against the clutch jaws, and slide clutch along shaft until jaws are completely disengaged. Be sure shafting is clean so jaw clutch will not bind to shaft. Oil the shaft with OE 50, or a lighter oil in winter, to facilitate moving the clutch.

10 (4) **Grease pillow block bearings.** Add WB 2 grease to pillow-block bearings until it squeezes out at ends of bearings.

Note. Do not lubricate underwater bearings, except when unit is taken out of service and emptied.

14 (5) **Service drive chain.** If the drive chain is slapping because of loose fit, remove a link from chain or raise drive unit by putting additional shims beneath it. When resetting drive unit, align drive sprocket on reducer shaft vertically with sprocket on head shaft. Check with plumb bob.

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	
				15		(6) **Grease drive chain.** Grease chain in cold climates to prevent freezing which causes chain to jump or break. Use CW 2, which sticks to chain for months and eliminates kinking.
				16		*b.* **Chain Belt Rex Types (M1 and ME).** (1) **Inspect flights.** Check for cracks. Make sure wood flights are securely fastened to attachments.
				17		(2) **Inspect drive chain.** Remove enough links to make it fairly taut. Replace damaged links promptly to relieve adjacent links and sprockets from unnecessary wear. Chains usually deteriorate when not used for a year or more. Remove such chains, coat with heavy lubricant or corrosion preventive, and store until needed. For further instructions on care of chains, see paragraph 19.
				18		(3) **Check sprocket condition.** Inspect sprockets for wear and alignment. When new chain is installed, see that sprockets do not have worn teeth. Hooked teeth grab or hold chain to sprocket and quickly ruin the chain. Replace sprockets if teeth have a marked hook shape. Correct misalignment of sprockets indicated by wear on the side of chain.
		11				(4) **Lubricate reducer.** Drain and flush reducer gear case. In normal ambient temperatures ranging from 50° F. to 100° F., use NS 5150. In low ambient temperatures ranging from 10° F. to 60° F., use NS 3080.
†						(5) **Check motor condition.** See paragraph 16.
1						*c.* JEFFREY TYPE. (1) **Lubricate Speed Reducer.** Check oil in speed reducer when idle to make sure of proper level. Do not fill reducer above specified oil level.
	4					(2) **Lubricate babbitted line-shaft bearings.** Lubricate bearings by adding WB 2 grease through Alemite fittings or other equivalent means. Where there is considerable dust, grease more frequently. Keep bolts and bearing caps tight.
		12				(3) **Inspect and lubricate antifriction line-shaft bearings.** Carefully inspect roller or ball bearings on line shafts to see that collars on each end of bearings are tight and keep sleeves from moving on the shaft. Grease roller or ball bearings quarterly. Never fill grease pocket around bearing more than two-thirds full. Use BR.
				19		(4) **Inspect underwater bearings.** Do not lubricate underwater bearings in normal use. However, when tank is out of service long enough for bearings to become dry, lubricate bearings with OE 10 before starting the equipment. Inspect to see that all bolts are tight and that bearings are properly secured to tank walls.
				20		(5) **Inspect collector chains.** Make sure chain slack is maintained.
				21		(6) **Inspect and replace wearing shoes.** Inspect wearing shoes on flights and replace if worn.
				22		(7) **Inspect and lubricate hinged flights.** Lubricate with water-pump grease, WP.
	5					(8) **Adjust and lubricate tightener.** Keep drive chains to drive sprockets fairly tight by adjusting chain tightener. Lubricate with CW 3.
				23		*d.* LINK BELT (STRAIGHTLINE TYPE). (1) **Tighten Chains.** Stretch chains tightly around sprockets with take-up shafts in extreme forward position and remove excess links if necessary. Where take-ups are not used, place chains

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	
						around sprockets and remove links until chain is tangent to guide angles on return run.
					*	(2) **Lubricate speed reducer.** Read lubrication instructions attached to speed reducer carefully. See paragraph 7 and table VI for proper lubricants.
	6					(*a*) Check oil level in the reducer.
					24	(*b*) Change oil.
	7					(3) **Grease bearings and sprockets.** Apply WB 2 grease liberally to drive sprocket and to all bearings above water level.
						(*a*) Grease bearings and movable parts.
						(*b*) If shear pin breaks or overload switch throws out, determine cause and remedy before starting collector again.
	8					(4) **Grease gears and chain drives.** For proper lubricants, see paragraph 7 and table VI.
					25	(5) **Drain basin and clean and inspect structure.** See paragraphs 11 and 56*g*.

58. Baffled Mixing Chambers

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	
				1		*a*. **Clean and Repair.** Drain and clean mixing chamber. Flush out sediment, mud, scale, etc. Examine baffle walls and make necessary repairs.
				2		*b*. **Examine and Lubricate Valves.** Carefully examine influent and effluent valves, lubricating and cleaning where necessary.

59. Mechanical Flocculation and Mixing Basins

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	
1						*a*. **Check Paddle Rotation.** When visual inspection or surface disturbances cannot show whether all flocculator paddles are rotating, check paddle movement by lowering a lightweight bamboo or similar pole into water over each paddle so that rotating paddle strikes the pole lightly. A broken shaft or chain may cause only one or two paddles to be inoperative.
						Caution: Do not use this paddle rotation check on high speed mixers.
				2		*b*. **Drain Basin and Clean and Service Mechanism.** Drain basin and thoroughly clean out sediment, algae, and other objectionable accumulations. Inspect concrete, valves, baffling, piping, chain, shafting, sprockets, bearings, impellers, gears, paddle, and other mechanical parts for deterioration (see par. 57). Make replacements where necessary.

60. Up-flow Sludge Contact Type Basin

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	
1						*a*. **Check Sludge and Sample Valves and Piping.** Make sure valves and piping are not dripping or leaking. See that sludge valves are opening and functioning properly. Check for proper operation of time clock and other accessories which control sludge-valve operation.
				2		*b*. **Drain Basin and Clean and Inspect.** Drain basin, clean, and carefully inspect all wearing parts. See applicable parts of paragraphs 11 and 56. See that chemical feed lines into basin are not clogged, are properly anchored, and are in good repair.

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	Item
			1			61 a
					2	61 b

61. Clear Wells

a. **Inspect Manholes and Vents.** Protect manholes leading into clear well or basin so ground water cannot enter. Either raise manhole sufficiently above ground level to prevent flow into well or seal covers with watertight material. Locate air vents to well so ground water cannot enter, and protect vents with screening. If vents are not located in pipe gallery, protect them against closure by frost formed by escaping moist air.

b. **Drain and Clean.** Inspect walls, floor, and ceilings for leakage into or out of basin. Look carefully for possible water contamination in the basin. (See also pars. 11 and 56.)

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

SECTION XVI
CHEMICAL FEEDERS

62. Gas Chlorinators

1 *a.* **Inspect for Leaks.** Examine chlorinator (fig. 51) and all piping for chlorine or water leaks. All chlorine leaks are serious, because they increase rapidly in size and cause extensive corrosion and damage. Red discoloration means scale.

To locate chlorine leaks, hold mouth of unstoppered ammonia-water bottle near all joints, valves, and along piping; white fumes of ammonium chloride indicate a leak. An aspirator type bottle may be more convenient. Keep ammonia bottle tightly stoppered when not in use to prevent loss of strength. Use litharge and glycerin cement in making metal screwed-pipe connections.

2 *b.* **Operate Chlorine Valves.** Open and close all chlorine valves to prevent threads on valve stem from becoming set in one position. Do not use force in closing a valve. Check stuffing boxes.

23 *c.* **Check Water System.** Clean water strainers and check pressure-reducing valve for proper operation. See that float valves are properly controlling water

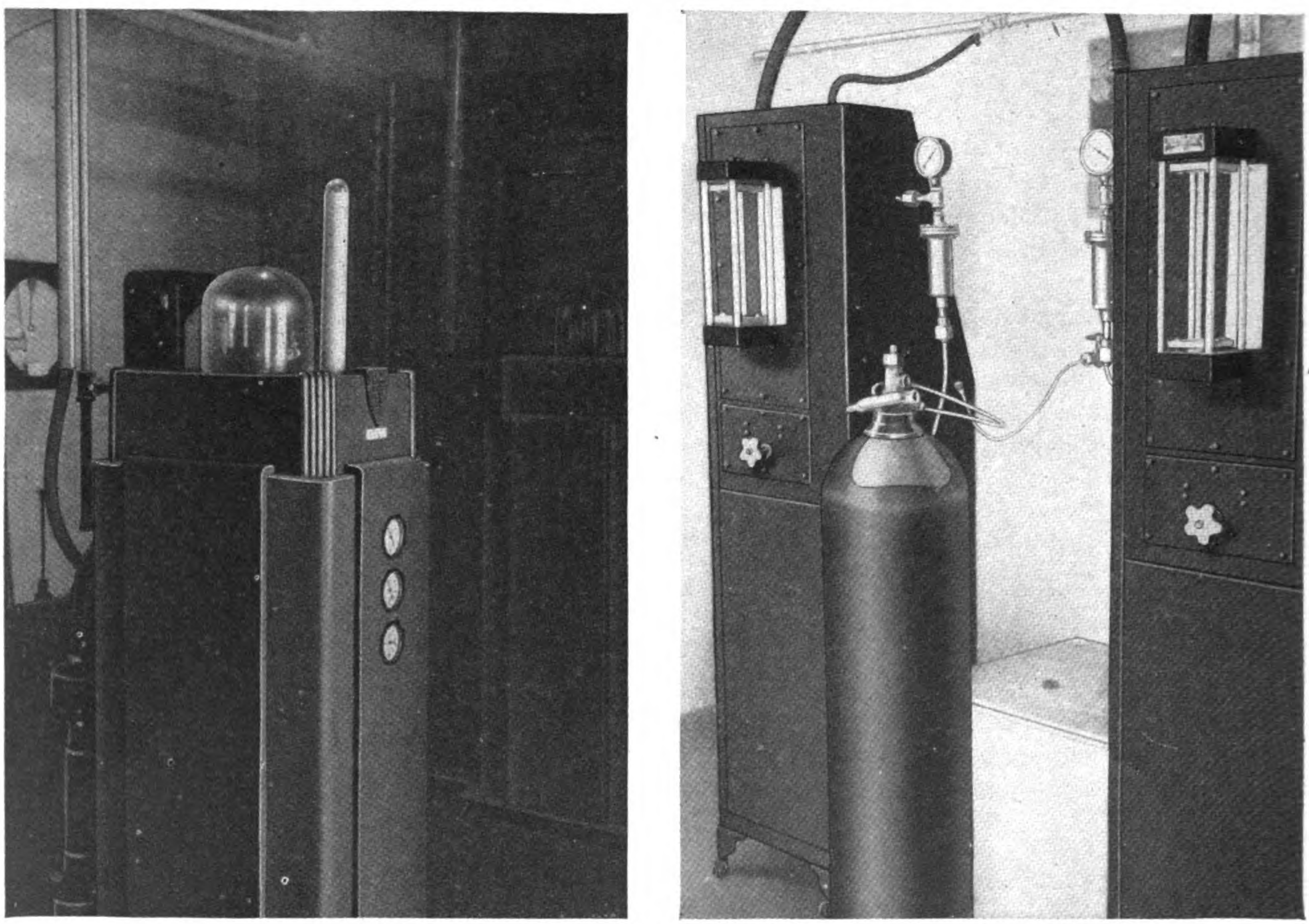


Figure 51. Typical chlorinator installations.

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

levels and that leakage and splashing is at a minimum. See that water flowing to waste is not excessive and that water levels are kept at their proper elevations. See that ejectors have their original capacities. If they do not, remove and clean with muriatic acid.

3 *d.* **Check Gas System.** Check that all parts carrying chlorine gas are operating properly. See that metering devices, pressure-reducing and shut-off valves, tubing, and so on function properly. Disassemble and clean where necessary, determining cause of the fault.

13 *e.* **Clean Cabinet and Critical Working Parts.** Thoroughly clean chlorinator cabinet, glass parts, floats, metering devices, and other parts in which dirt might interfere with operations or make equipment unsightly. Cover unpainted metal subject to corrosion with film of petrolatum or similar protective compound.

28 *f.* **Disassemble or Operate Important Hard-rubber Threads, Valves, and Parts.** Hard-rubber threads or parts on a chlorinator freeze or stick when not operated for long periods, causing breakage when parts are disassembled. To keep threads from freezing, operate all parts needed to keep chlorinator in service. Before reassembling such parts, cover with graphite grease GH.

Caution: Use no tools on hard rubber parts, except for rare and careful use of a strap wrench. Tighten hard-rubber parts only fingertight. Cover pipe threads with graphite grease GH.

30 *g.* **Overhaul.** Remove chlorinator parts and clean thoroughly. Paint chlorinator cabinet inside and out with three coats of rust-resisting paint. Carefully examine each chlorinator part. Reassemble and check for proper operation.

(1) The only safe liquids for cleaning chlorine lines are wood alcohol and carbon tetrachloride. After cleaning, allow it to evaporate to dryness. Ethyl alcohol or ether are converted by chlorine into solid waxy substances. Water combines with chlorine to form a highly corrosive substance.

(2) Oil or grease react with chlorine to form a voluminous frothy substance. Therefore, they should not be used as lubricants at points where they may come into contact with chlorine.

(3) Condensation forming on chlorine-cylinder walls may corrode scales and other equipment around the cylinder. Guard against such damage by improving ventilation around the cylinder to keep surfaces dry. An electric fan may suffice. Do *not* apply direct heat to dry the cylinder.

(4) It is dangerous to attempt to increase the rate of gas withdrawal by heating chlorine cylinders or containers above normal room temperature with hot-water baths or other means. Inspect regularly to see that chlorine cylinders are not near steam or hot-water lines or other sources of heat.

(5) Use a new lead gasket in connecting valve or tube and when replacing empty chlorine cylinders. Use only one lead gasket.

4 *h.* **Check Vacuum Relief.** Make sure assembly operates properly and relief-hose line is not plugged. Insects such as mud daubers may plug lines by building nests in them.

31 *i.* **Examine Solution Tube.** Check tubing for abrasion that might cause leaks. Inspect tubing for kinks or for mineral deposits restricting discharge. Remove iron or manganese deposits from diffuser tube by adding 10 percent solution of

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

hexametaphosphate or septaphosphate to make-up water, at rate of 1 drop per minute. To add reagent, attach rubber hose to bottle containing treatment solution, and place pinch clamp on rubber hose. Invert bottle and adjust pinch clamp for proper feed rate.

63. Gas Ammoniators

5 *a.* **Inspect for Leaks.** Examine ammonia and water piping, valves, and fittings for leaks.

(1) Leaks in ammonia piping may be detected by odor or watering of the eyes. They may be located by white smoke produced when a bottle of hydrochloric acid, strong chlorine water, or a burning sulfur stick is held near the leak. Moist phenolphthalein paper is turned red by ammonia gas.

(2) Correct leaks around valve stems by tightening packing-gland nut.

(3) Stop leaks at screwed-pipe connections by using litharge and glycerin cement when making connections.

(4) Use either lead or asbestos composition gaskets on flanged fittings.

(5) Use new gasket if tightening union nut does not stop leak at union.

(6) Do all soldering with pure lead.

(7) Use especially designed steel for new or replacement valves in ammonia lines because copper and brass corrode very rapidly in presence of moist ammonia.

14 *b.* **Operate Ammonia Valves.** Close and open all ammonia valves to prevent sticking. Do not use force in closing a valve which is in good condition. Operate ammoniator briefly at maximum capacity, checking for operating defects.

15 *c.* **Clean Cabinet and Critical Working Parts.** Thoroughly clean ammoniator cabinet, glass parts, metering devices, and other parts which might interfere with operations or make equipment unsightly. Coat unpainted metal subject to corrosion with vaseline or similar protective compound. Do not use water to clean any apparatus except glass parts. See that all metal parts coming in contact with ammonia are dry. When a liquid cleaner must be used, use carbon tetrachloride and allow it to evaporate to dryness.

32 *d.* **Overhaul.** Remove all ammoniator parts, examine, and clean. Reassemble and check for proper operation. Clean and touch up exposed metal spots of cabinet and pedestal. Repaint inside and out with enamel.

33 *e.* **Check Manometer oil.** Be sure true manometer oil is used.

64. Pump Type Solution Feeders (fig. 52)

6 *a.* **Check Operation.** Inspect sight-feed indicators to insure that solution is being fed.

(1) See that automatic controls start and stop properly.

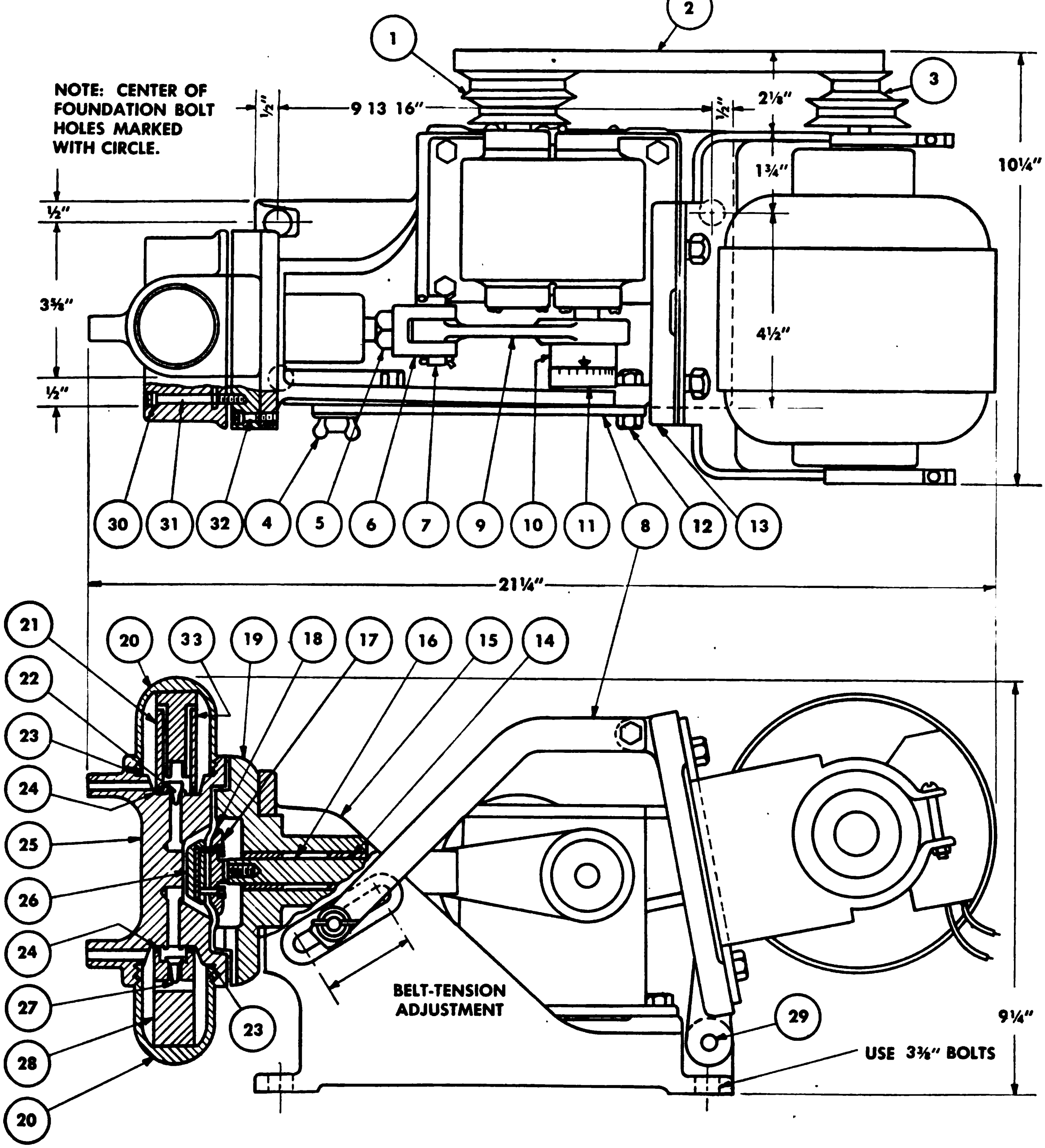
(2) Make sure there is enough prepared solution.

(3) Check for leaks in piping joints and packing glands.

16 *b.* **Clean Feeder.** Remove and clean glass and plastic parts of sight-feed indicator. Remove white coating caused by hard water in hypochlorite solutions by soaking in 5 percent solution of muriatic acid.

24 *c.* **Clean and Flush Solution Tank.** (1) Clean suction strainer and hose.

(2) Disassemble, inspect, and clean solution diaphragm chambers and check valves.



(1) Three-step V-belt pulley (½″ bore).
(2) V-belt.
(3) Three step V-belt pulley (½″ bore).
(4) 5/16″ 18 x 1″ long, square-head bolt and wing nut.
(5) Clevis nut.
(6) Clevis.
(7) Clevis pin.
(8) Motor adjusting bar.
(9) Eccentric link.
(10) Outer eccentric (complete).
(11) Inner eccentric (complete).
(12) 5/16″ 18 x 1″ long, round-head screw and nut.
(13) Motor base.
(14) Push-rod bushing.
(15) Support frame.
(16) Push rod.
(17) Reagent-diaphragm push plate.
(18) Reagent diaphragm.
(19) Diaphragm base.
(20) Check-valve cap.
(21) Upper check-valve socket.
(22) Weighted valve tit.
(23) Check-valve-cap gasket.
(24) Check-valve-socket washer.
(25) Reagent-diaphragm.
(26) Reagent-diaphragm clamp.
(27) Check-valve tit.
(28) Lower-check-valve socket.
(29) Motor-base pivot pin.
(30) Diaphragm cap-screw washer.
(31) 10–32 x 1¾″ long, round-head machine screw.
(32) No. 10–32 x ¾″ long, filister-head machine screw.
(33) Sight-feeder intensifier.

Figure 52. Pump-type solution feeder.

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

(3) Clean screens and strainers on water-operated feeders.

(4) Exercise all shut-off valves and stroke controls.

34 *d.* **Overhaul feeder.** (1) Replace worn parts and packing.

(2) Clean screen in water meter.

(3) Touch up and paint all metal parts.

† *e.* **Check Mechanical Drives.** For maintenance of motors, belts, and mechanical parts of driving mechanisms, see section IV.

65. Proportional Type Solution Feeders

7 *a.* **Inspect Sight-feed Indicators.** Make sure solution is being fed. Check operation of unit.

(1) Observe changes in rate of feed under varying rates of flow through prime control.

(2) Check sufficiency of prepared solution or solid chemical in feeder.

(3) Check for leaks in piping joints and gaskets.

17 *b.* **Clean Feeder.** Remove and clean sight-feed indicator glass and plastic parts. (See par. 64*b*.)

(1) Clean and flush solution tank or solid chemical dissolving compartment.

(2) Clean screens and strainers on water lines.

(3) Operate all shut-off and rate-control valves.

29 *c.* **Inspect Interior.** Look for breaks in special lining. Check for corrosion. Where lining has deteriorated, clean to bare metal and reline with Lin-tite, following manufacturer's instructions.

35 *d.* **Overhaul Feeder.** (1) Remove, inspect, and clean all bag diaphragms.

(2) Remove, inspect, and clean all orifice plates, needle valves, etc.

(3) Touch up all metal parts with paint.

66. Volumetric Dry Feeders

8 *a.* **Clean and Inspect.** Clean feeder, feeder mechanism, and feeder surroundings. Remove spilled chemical and chemical-dust accumulations with vacuum cleaner or brush. Look for oil drips, wiring defects, and deterioration. Observe general performance of feeder. Note and investigate unusual noises. See that orifice, knife edges, scrapers, shakers, and opening are free of chemical accumulations. Probe solution tank for sediment or undissolved chemical and make necessary corrections. Be sure that hopper fills are made without chemical spillage on working parts of feeder (fig. 53). If chemical feeder is out of service, see that feeder is empty of chemical and that condensation is not causing deterioration.

18 *b.* **Inspect for Loose Bolts and Cracks.** Carefully wipe all parts of feeder. Inspect for loose bolts, cracks, defective parts, and leaks.

25 *c.* **Test Calibration.** Make several calibration tests, using range of feed in which chemical feeder operates most frequently, to check accuracy of rate-setting devices, charts, or tables.

(1) *Test with feeder not on scale.* With chemical feeder off scale and delivering uniformly after a change in rate of feed, catch delivery in pan for a known period of time. Weigh material caught, and calculate feed in pounds per hour. Compare with indicated rate setting or chart. Be careful and accurate

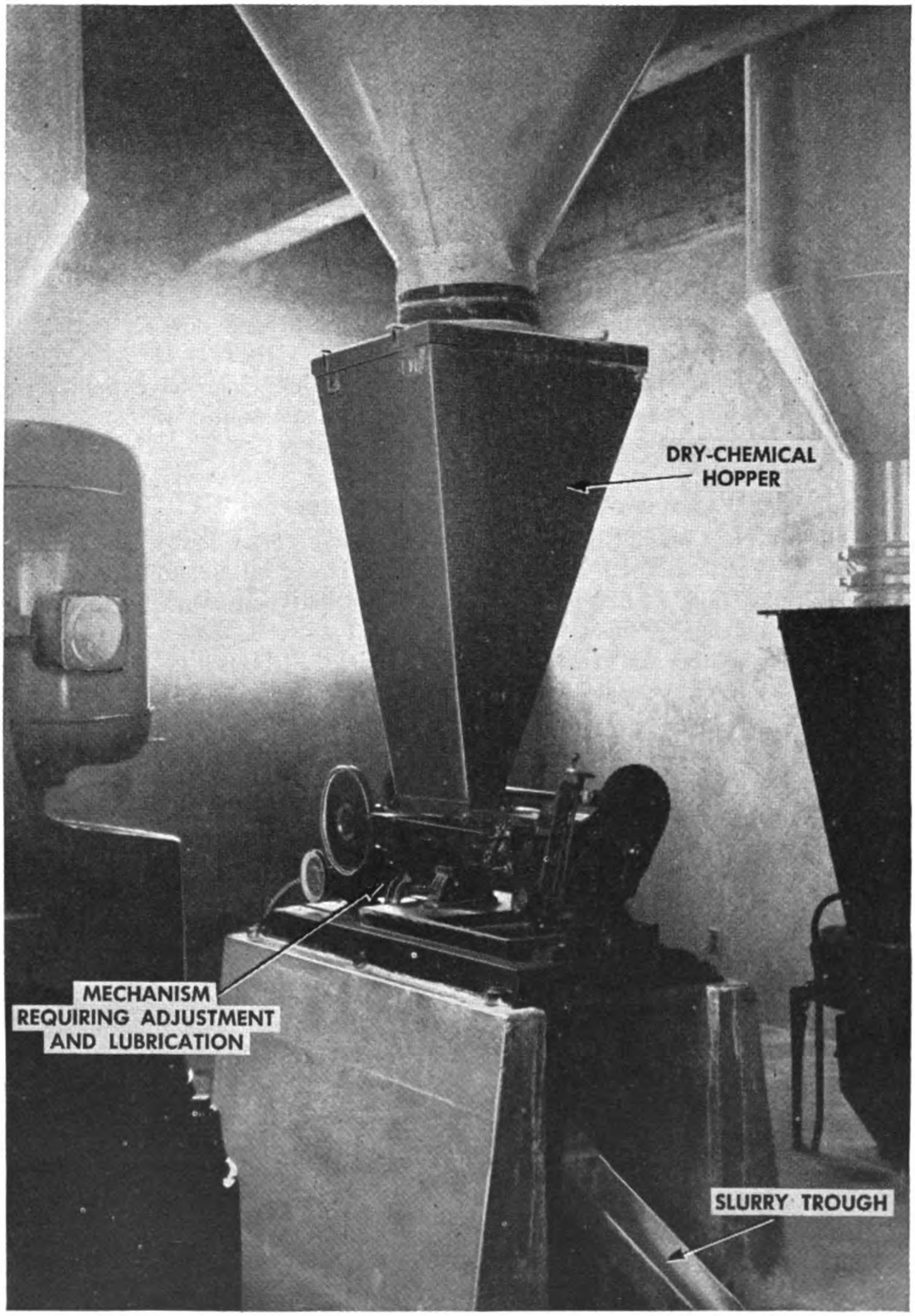


Figure 53. Dry chemical feeder installation.

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

in timing, weighing, and collecting material. Perform each test several times to check results.

(2) *Test with feeder on scale.* With feeder on weighing scale, check rate of feed by stopping feeder, balancing scales, and then running feeder for a known period of time. Stop feeder and rebalance scale. Subtract this reading from previous scale reading to determine amount of chemicals that passed through hopper in the given time.

† *d.* **Service Drive Mechanism and Moving Parts.** Follow manufacturer's instruction in servicing drive mechanism and moving parts. (See also par. 7, table VI, and sec. IV.)

36 *e.* **Overhaul.** Overhaul chemical feeder, clean, and paint interior and exterior. Clean and repair solution and make-up tanks. Service drive-mechanism bearings and other mechanical parts.

67. Gravimetric Belt Type Dry Feeders

9 *a.* **Clean, Check, and Test Balance.** Clean feeder, feeder mechanism, and surroundings. Empty feed belt, clean off accumulations, and test scale balance with zero load. Make necessary adjustments to correct tare-weight balance. Check for mechanical and electrical defects and for proper operation. Look for oil drips and wiring defects. Observe general performance and investigate unusual noises. Make sure chemical is not accumulating on inner roll of belt or adhering to belt in a manner which may cause too high a tension or tare.

* (1) **Check solution tank.** Probe solution tank for sediment or undissolved chemical. Clean and improve dissolving conditions if necessary.

* (2) **Check feeder out of service.** If chemical feeder is out of service, see that feeder belt is empty of chemical and that condensation is not causing deterioration.

19 *b.* **Inspect for Loose Bolts and Defective Parts.** Carefully wipe all parts of feeder, inspecting for loose bolts, leaks, defective parts, and so on. Check belt tension.

37 *c.* **Overhaul Feeder.** Remove feeder-belt assembly, motors, belts, and the like where practical and overhaul feeder completely. Clean and paint entire structure. Clean scales, and edges, and test for sensitivity. Lubricate all mechanical parts, and make necessary repairs. (See pars. 18 and 19.)

26 *d.* **Make Delivery Test.** To locate feeder abnormalities, test delivery of feeder to see that its actual output is equal to weight indication totalizer or integration device.

(1) Clean belt and feeder and then balance scale. Return feeder to service and operate until chemical forms an even, uniform layer on feeder belt and scale remains in close balance. See that poise on scale beam indicates proper load on belt.

(2) Stop motor. See that scale with its load of material moves freely and is in exact balance. If it is not, add or remove material from *rear* end of load on belt until exact balance is obtained.

(3) Disengage or stop operation of mechanism which feeds chemical to belt. Read belt revolution counter or weight integrator. Then operate feeder belt until counter or weight integrator indicates that exactly a predetermined

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number of pounds of chemical, about two-thirds of belt loading, have been fed. Stop feeder instantly by turning off motor switch.

(4) Again see that scale can move freely and then move poise to bring scale back to exact balance. Note scale reading. The difference between this scale reading and initial scale reading gives exact weight of material which has been delivered.

(5) If this reading does not coincide with number of pounds as shown by revolution counter, adjust as follows:

(*a*) If actual delivery as shown by front scale beam is greater than indicated by revolution counter, move poise on scale beam to a lower figure so belt loading is less and repeat test.

(*b*) If actual delivery is less than indicated by revolution counter, move scale poise to higher reading on scale beam so belt loading is greater and repeat test.

(6) Continue testing until a belt loading is found which results in delivery of material corresponding exactly with reading of revolution counter. When this location is determined, set and clamp poise on scale beam at this position, and record setting for future reference. Thereafter when feeding same sort of material, use same belt loading. Recalibrate when using a different sort of material which has a different degree of slope at which material falls off front end of feeder belt.

Note. For certain other belt type feeders, a delivery test can only be made by catching delivery during an exact test period and weighing the catch. Actual delivery rate of feeder can be calculated from these data.

68. Loss-in-weight Type Gravimetric Feeder

10 *a*. **Clean and Check.** Clean feeder, feeder mechanism, and surroundings. See that scale is sensitive to small changes in weight. Whenever feeder is empty, determine tare weight or see if scale indicates zero weight. Look for oil drips and wiring defects. Observe general performance of feeder. Note and investigate unusual noises. See that chemical is not accumulating on parts of the feeder, changing tare weight of scale. Probe solution tank for sediment or undissolved chemical. Clean and improve dissolving conditions if necessary. If chemical feeder is out of service, see that hopper is empty and that condensation is not causing feeder deterioration.

20 *b*. **Inspect for Loose Bolts and Defective Parts.** Carefully wipe all parts of feeder, inspecting for loose bolts, leaks, defective parts, and the like.

† *c*. **Service Drive Mechanism and Moving Parts.** Service drive mechanism and moving parts according to manufacturer's instructions. (See also par. 7, table VI, and sec. IV.)

38 *d*. **Overhaul Feeder and Scale.** Disassemble feeder and inspect for worn or deteriorated parts. Clean and paint feeder inside and out where necessary. Make necessary repairs and properly lubricate all mechanical parts. Service motors and drive mechanism.

69. Continuous Lime Slakers

11 *a*. **Check Dust and Vapor-removal Equipment.** For clean, trouble-free operation of quicklime feeders and slakers, keep dust removal equipment operating properly. Spend at least 10 or 15 minutes of every shift checking and cleaning

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

dust removal device to prevent steam and moisture from surrounding feeding mechanism, causing rusting, premature slaking of lime, and formation of pastes.

12 *b*. **Remove Clinkers.** Use hoe or other means to remove rocks, clinkers, and heavy sediment from slaker. Keep hoe away from agitators or mixers. In most limes, few clinkers will be found, especially when agitation is of high-speed type.

21 *c*. **Clean Slaker.** When slaker is out of service, but not necessarily drained, thoroughly clean each compartment of rocks and accumulated sediment. Carefully clean slaker externally. Use rag oiled with ordinary lubricating oil to wipe off lime feeders and slakers. Quicklime splashing on oily surface does not stick to or affect paint and can be wiped off easily.

(1) *Check shut-off, float, and check valves for leakage.* Operate all valves not in daily use. Check for leakage. Clean where necessary.

(2) *Clean vapor-removal apparatus.* When slaker is out of service, remove inspection or cleanout covers and plates from vapor-removal apparatus and clean interior. With covers removed, check mechanism for proper functioning.

27 *d*. **Inspect Agitators, Stirrers, and Heat-exchanger Coils.** Once a month or oftener, drain slakers to examine and clean any copper heat-exchanger coils and check impellers or stirring mechanism. Replace worn impellers where necessary. High-speed impellers on some slakers can be checked without draining slaker by unbolting agitator-shaft bearings and withdrawing agitator shaft with its impeller. If baffles in front of copper heat-exchanger coil are wearing through or improperly shield copper coils from abrasive action of impeller jet, replace them or change position as necessary.

39 *e*. **Overhaul.** Drain and thoroughly clean slaker and dust-evacuator system. Examine sides and bottom of slaker for wear and make necessary repairs. Paint slaker lids, inside top edges, and outside to prevent corrosion. Examine and test heat exchanger for leaks and objectionable incrustation. Clean thermometers and test against laboratory thermometer. Disassemble bearings, clean, and lubricate. Clean and repair screen, piping, floats, valves, and controls.

22 *f*. **Clean and Inspect for Corrosion and Mechanical and Electrical Defects.** Clean carefully. Inspect for leaks, wiring defects, metal deterioration, and vibration. Tighten all nuts and bolts. Check belt tension. Paint where necessary to prevent corrosion.

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

SECTION XVII
FILTERS

70. Pressure Filters

The filtering material generally used in pressure filters (fig. 54) consists of sand, anthrafilt, and gravel. It must be kept clean, loose, and free of mud balls. Care of the filtering medium in pressure filters is similar to that in gravity filters (par. 71*a*). However, in pressure filters backwashing the filtering medium cannot be observed and consequently a great deal of care and thoroughness must be exercised during the periodic inspections. Continued dependable functioning of pressure filters depends on internal filter inspection.

2 *a*. **Inspect Sand or Anthrafilt Surface.** After back washing filter in the regular manner, remove access manhole plates and with aid of a strong light, examine sand surface for dirt, cracks, mud balls, or uneveness. Do not enter the filter unless it is to be disinfected before being returned to service. Measure sand-surface elevation from some convenient reference point. Compare with measurement made the previous month.

If sand-surface inspection shows need for cleaning, scour sand surface with a pressure water hose and then backwash filter through access manholes to make higher backwash rate possible. Proper backwash rate often throws a little sand out of filter.

11 *b*. **Observe Condition of Gravel Bed.** Backwashing a pressure filter too violently and at too high a rate or operating it beyond a 5-pound loss of head results in an upset or broken gravel bed. Inspecting gravel bed of a pressure filter is difficult because sand must first be removed from the gravel. Therefore, condition of gravel bed is usually observed by noting whether condition of sand bed or anthrafilt indicates uniform distribution of wash water; condition can also be determined by noting whether effluent contains sand or fine gravel. When condition of sand bed shows that wash water distribution is not uniform or when sand is found in filter effluent, complete removal and replacement of filtering medium is usually advisable.

* *c*. **Inspect Filter Bottom.** Check condition of filter bottom every 3 years, and whenever filtering medium is removed from filter. Examine each orifice or water passage in bottom to make certain it is open. Turn on wash water and watch backwash water distribution through bottom. Clean out wash water distribution piping if necessary. Apply a good protective paint or coating to parts of underdrain system which are subject to corrosion.

12 *d*. **Check Pressure-filter Shell.** Paint the exterior of filter with two or three coats of protective paint. Paint inside of filter each time it is overhauled.

1 *e*. **Check Pressure-filter Piping.** Inspect piping for leaks. Operate all filter valves and adjacent hand-operated valves. Lubricate and repack where necessary.

71. Gravity Rapid-sand Filters

a. General. The filtering medium of a rapid-sand filter (fig. 55) consists of sand or anthrafilt supported on a gravel bed. For satisfactory filtration, this filtering medium must be kept free from dirt, hard spots, mud balls, or objectionable incrustation.

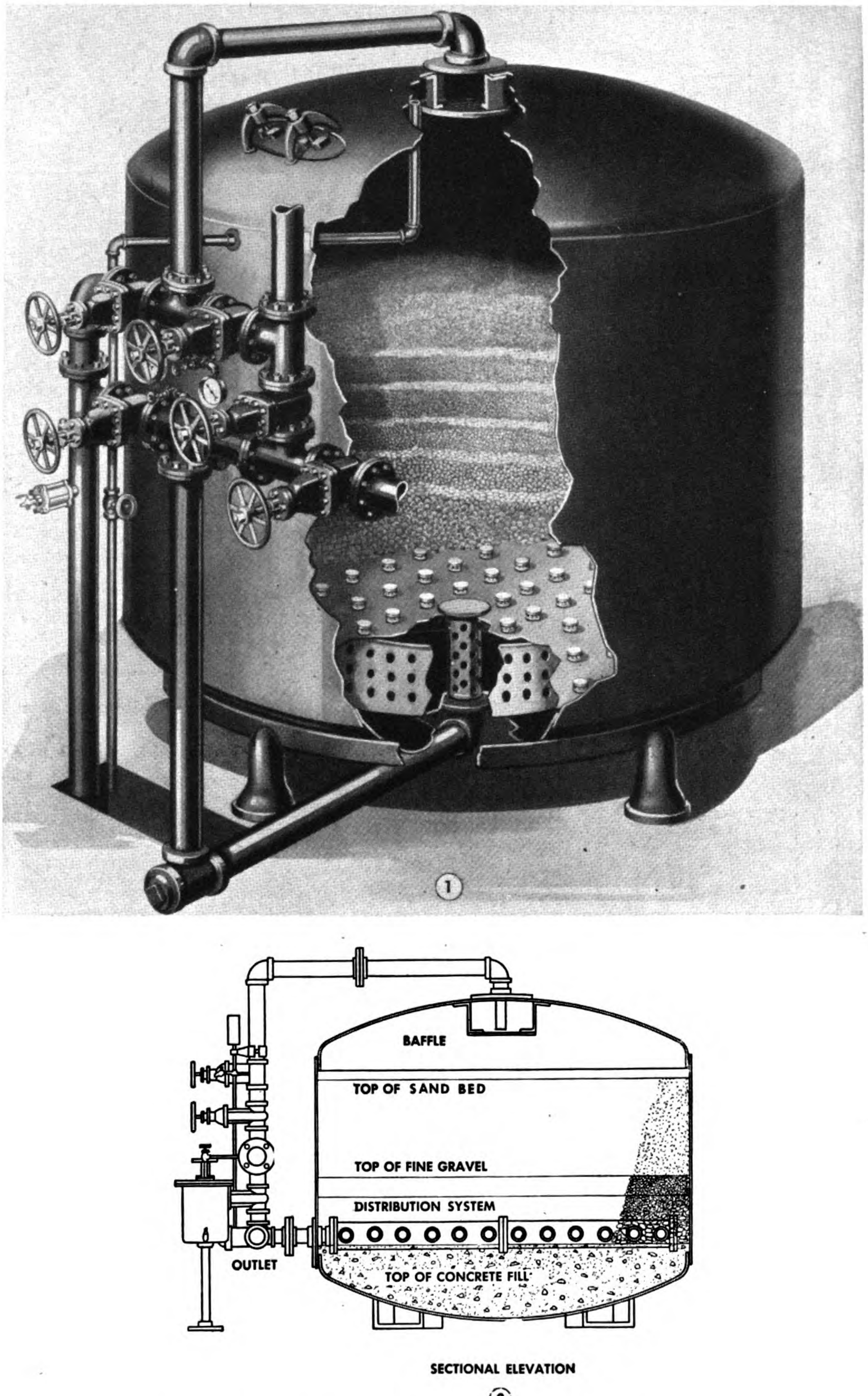

Figure 54. Cross section of vertical-pressure type water filters.

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

(1) *Backwashing.* Filters are surfaced-washed and backwashed to remove accumulated dirt from the filter medium. A filter which is not properly cleaned during backwashing soon cakes and cracks, allowing unfiltered water to pass through. However, normal filter washing alone is not enough to maintain the filter bed under all conditions, and regular inspections and maintenance are needed in addition to insure that the filter beds remain loose, clean, and free of incrustation.

(2) *Sand disinfection.* Filter sand must be disinfected if it becomes covered with slime or algae growths or if it has been contaminated by workmen entering the filter. For complete disinfection, chlorine is added and the sand agitated by compressed air or a water jet.

3 *b.* **Inspect Sand or Anthrafilt Surface.** After backwashing thoroughly, drain water from filter bed and carefully observe surface of sand for unevenness, sink holes, cracks (especially along walls), mud balls, algae, and slime.

(1) Depressions or craters in sand surface usually indicate a loose strainer cup or a break in underdrainage joints. Make necessary repairs.

(2) If mud balls or cracks are found, surface-wash thoroughly before backwashing thereafter.

(3) If sand is slime- or algae-covered, chlorinate heavily, following procedure below. Lower water level in filter to about 6 inches deep above sand bed and add HTH or Perchloron until water contains 2 to 4 parts per million of chlorine. Open filter to waste valve and draw the water level to within 1 inch of sand. Allow filter to remain idle for about 6 hours, then stir surface sand thoroughly, using a pressure water hose or heavy rake. Backwash the filter and return it to

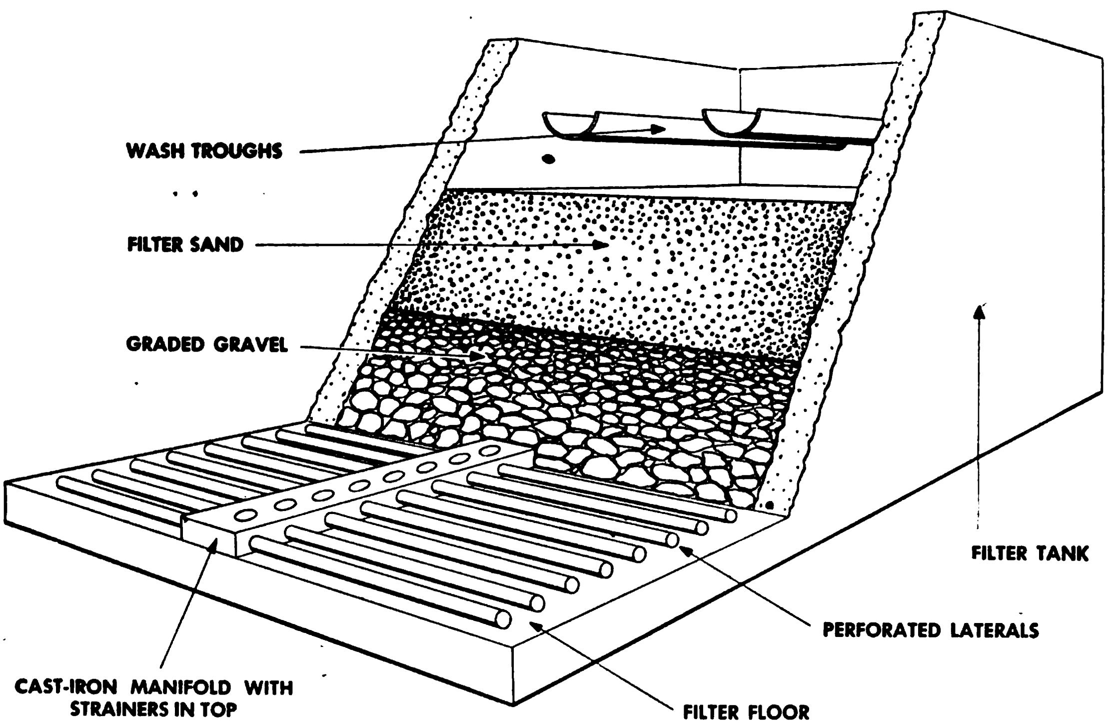

Figure 55. Cut-away view of gravity sand filter, showing underdrains and filter bed.

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DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY

service. If initial treatment is not effective, increase chlorine dosage. With some types of algae, copper sulphate may be more effective than HTH or Perchloron.

(4) Measure distance from sand level to top lip of wash-water troughs on each filter, and compare with measurement made the previous month. Change in sand level indicates that sand is bulking because of incrustations or is being lost during backwashing.

5 *c.* **Probe Filter.** While filter is being washed, probe for hard spots by jabbing a pole vertically through the sand. Pole should sink to the gravel with practically no resistance from the sand. If it does not, investigate gravel and filter bottom.

6 *d.* **Inspect Sand Below Surface.** Dig carefully through sand bed so cross section of bed can be seen. *Do not disturb gravel.* Examine bed for mud balls, hard spots, and other signs of sand-bed deterioration, especially near surface and at bottom, just above gravel. Chemical treatment with caustic soda, sulfur dioxide, or chlorine may sometimes restore sand satisfactorily. However, if deterioration is caused by a fault in underdrain system, chemical treatment may give only temporary improvement. If sand is in poor condition, it is usually better to replace entire filtering medium.

7 *e.* **Scrub Sand.** If inspection reveals presence of hard or soft mud balls, cracks in sand bed, caked sand, or other signs of a dirty filter, water-jet sand from one side of filter to the other so sand washes horizontally through a $\frac{1}{8}$-inch mesh screen which has been set on a 45° slope. Under severe conditions, first treat sand with sulfur dioxide or caustic soda to condition the sand properly. Do not attempt this conditioning treatment unless fully familiar with these chemicals. Under extremely severe conditions, replacement of filtering medium may be required.

8 *f.* **Analyze Sand.** Make sieve analysis and determine loss of weight during acid digestion as follows:

(1) *Sample collection.* Collect representative sample of sand by means of a thin-wall steel pipe or tube about 12 inches square and 36 inches long, open at both ends. Force pipe through sand bed down to gravel, drain water from sand bed, and with a small shovel or dipper scoop all sand from inside the tube. Collect a total of about 1 or 2 pounds of sand in this manner from several places in filter, quartering the larger sample collected.

(2) *Sieve analysis.* Run part of sample through sieve to determine whether effective size and uniformity coefficient of sand has changed. Change in either shows that small-sized sand particles are washing out, or incrustation, cementation, or other filter-bed deterioration is taking place.

(3) *Acid loss of weight test.* Find loss of weight during acid digestion by carefully weighing about 10 grams of dried sand into a pyrex evaporating dish, covering with 10 percent hydrochloric acid, and digesting on a water bath for 24 hours. Add acid from time to time to replace loss in volume of acid during digestion. After digestion wash sand carefully and thoroughly by decantation, dry it, and weigh. Compare results with last determination of loss of weight during acid digestion to see whether there is any change in amount of incrustation taking place on sand.

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

(4) *Results*. Study results of both tests to determine whether change in chemical treatment of water is necessary, surface-washing and backwashing are adequate, and whether sand requires restoration treatment.

4 *g*. **Inspect Gravel-bed Level.** To learn whether gravel-bed surface is level or ridged and whether it has shifted during backwashing, insert a probing stick through sand bed down to the gravel while filter is being washed. Mark water elevation on stick. Probe at as many points as possible, each time recording water level on the stick. If water-level marks are at different points on the stick, gravel bed is uneven and filter needs overhauling.

9 *h*. **Check Gravel Bed.** Shovel filter sand away from gravel bed for a 2- or 3-foot-square area, taking care not to shovel into or disturb the gravel. Dig into gravel with bare hands to see whether gravel is cemented, uneven, and whether larger-size bottom gravel is mixed with smaller top gravel. Repeat inspection in another portion of the filter. Inspection indicates whether wash-water rates are so high that gravel bed is being moved, whether gravel incrustation is serious, and whether backwash-water distribution is seriously uneven. Revise water-pretreatment and filter-washing procedures if results of inspection warrant it.

13 *i*. **Inspect Filter Bottom.** Complete inspection of a filter bottom usually involves moving the graded gravel resting on the bottom. Since replacing this gravel properly is extremely difficult and since materials used to build filter bottoms are usually noncorrosive and durable, the bottom is usually inspected only when backwashing performance or general filter operations show it to be necessary. For example, filter bottom should be inspected when backwash water spurts or rises in fountains, or when there are craters in the sand surface. Whenever inspection is made, provide means for regrading and replacing the entire gravel bed, if found necessary.

(1) To inspect filter bottom, remove about 10 square feet of sand from gravel surface. Place planking on gravel to support weight of inspector, leaving a 2-foot-square opening in center. Remove gravel from opening in layers, using the hands or a small shovel. Inspect bottom for clogged orifices and ports and for general deterioration.

(2) Remove clogging caused by alum-floc penetration of porous-plate underdrain system by overnight saturation with a 2 percent sodium hydroxide. This can be done without removal of filter medium. To restore other type filter bottoms, remove filter medium and overhaul completely.

72. Wash-water Troughs

10 *a*. **Inspect Level and Elevation.** See that wash-water troughs are level and at the same elevation by noting whether or not wash water spills over the entire length of each trough and into all troughs at the same time. To make test, first draw water in filters below level of lips of troughs, with wash-water rise being comparatively slow. If wash-water troughs are not level, get them into proper position to prevent uneven filter-bed washing.

14 *b*. **Inspect for Corrosion.** Inspect steel wash-water troughs for corrosion or pitting. If necessary, cover troughs with protective paint or other coating.

73. Operating Tables or Panels

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	
		1				*a.* **Clean Operating Tables and Panels** (fig. 56). Scrub inside and out with soap and water or polish as necessary. Remove pens from recording instruments, wash out, and replace. If any ink is spilled, wash off immediately with water.
		2				*b.* **Tighten Cables and Chains.** Check tension in wires, cables, and chains, including those used to indicate valve position, control fluid counterweight buckets, etc. Take up slack if necessary.
		3				*c.* **Check for Leaks.** Examine transfer valves and other piping in and around operating tables for leaks. Take necessary steps to stop dripping. In case of leakage around stem on transfer valves, tighten packing gland slightly by hand until leak stops, then back off slightly so stem is not bound.
					7	*d.* **Paint.** Paint all metal on table panels interiors to protect against corrosion.
		4				*e.* **Adjust Transfer (Four-way) Valves and Handles on Operating Table.** Adjust transfer valves so hydraulic filter valves open and close at same rate. Tighten transfer valves or install new packing to prevent leakage.
		5				*f.* **Lubricate.** Use CG 1 grease and the grease screw usually provided in front of valves to grease transfer valves which require lubrication. Do not neglect

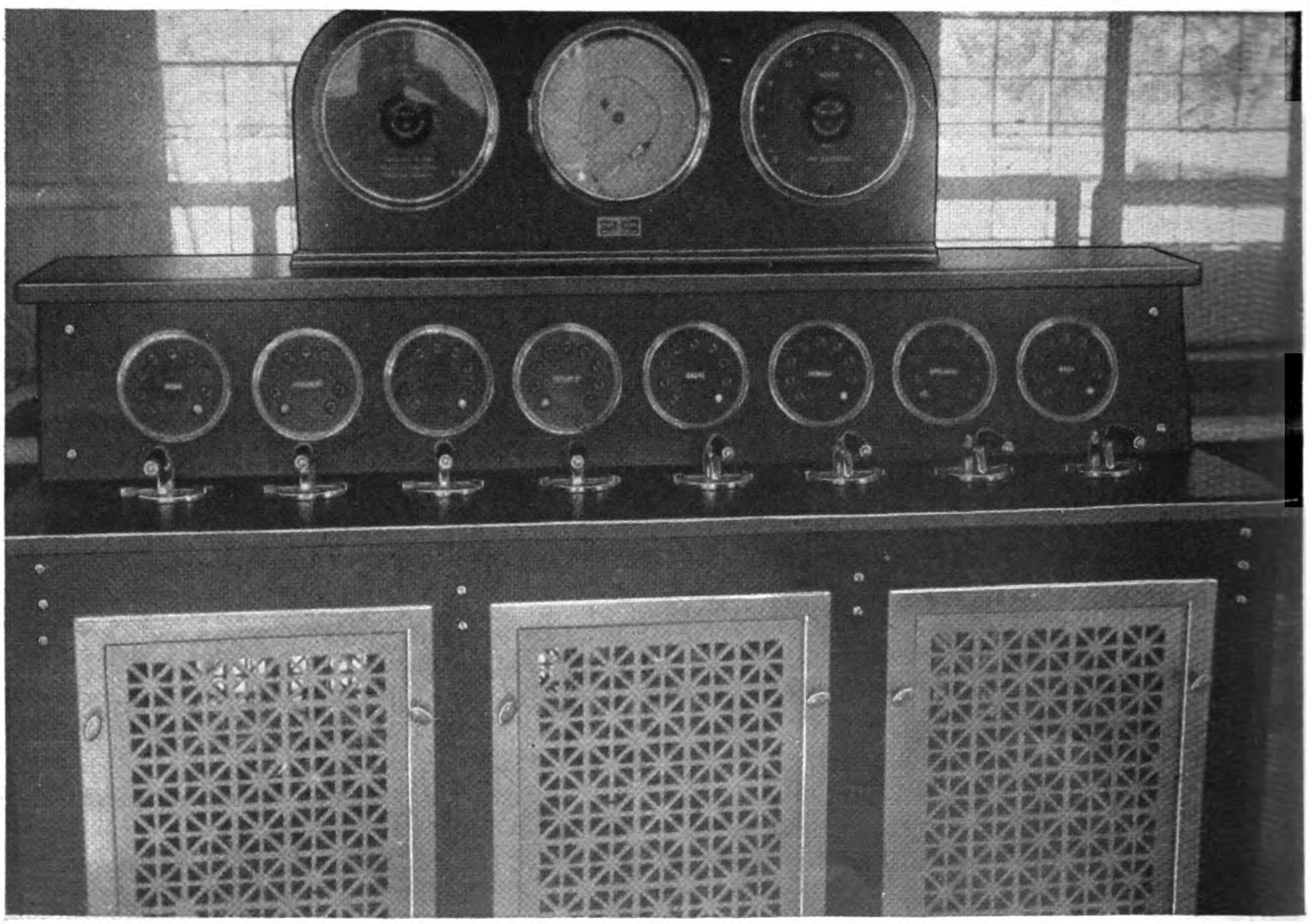


Figure 56. Filter operating table installation.

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

this lubrication as it prevents wear and corrosion. Do not overlubricate because grease will lift valve disk, causing temporary leaks in disk type valves. One-half turn of grease screw is generally sufficient.

8 *g.* **Disassemble.** Disassemble transfer valves and clean them thoroughly. Carefully examine seats, washers, or moving parts for wear, deterioration, and leakage.

6 *h.* **Check Valve-position Indicator.** Check that valve-position indicator on filter operating table is functioning and is accurate, reading "closed" when valve is closed and "open" when the valve is open.

74. Gauges and Controllers

5 *a.* **Check Zero of Service Filter Loss-of-head Gauge.** (1) **Check zero.** Open equalizing valve on mercury float type head gauges and see that loss-of-head gauge finger and recording pen return to zero. Note whether or not zero loss-of-head indication was incorrect because of position of stop collar on wire cable, and correct position of stop collar if necessary. Release air from floats and float chamber equipped with air release. On some floats, air can be released by giving the wire cable several light jerks.

6 (2) **Drain mud from collectors.** Water-pipe line from filter above sand to loss-of-head gauge is usually built with a mud leg or sediment collector. Drain until clear water runs out freely.

17 (3) **Clean float and mercury.** Open float chamber and remove float for cleaning and inspection. Wash float in water to remove dirt and slime. Clean float of incrustation if necessary, taking care not to mar or otherwise damage float and attachments. Some floats, such as hard-rubber floats, may be cleaned in acid. Empty mercury from float chamber and clean if necessary by method given in paragraph 9. Check that quantity of mercury conforms to name plate data or manufacturers' specifications.

18 (4) **Paint.** Paint interior and exterior of the float chamber and other parts of gauge to protect against corrosions.

19 (5) **Inspect pressure-pipe lines to float chamber.** See that pipe lines to loss-of-head gauge are open, free of incrustation, and that full stream of water flows through them freely. Clean if necessary.

7 *b.* **Inspect Diaphragm Pendulum Type Loss-of-head Gauge.** (1) **Check zero.** Check loss-of-head gauges with test pipe and at zero. Purge all diaphragm cases of air. Be sure cable comes off segment at a tangent to lower end when unit is at zero.

8 (2) **Examine knife edges.** Remove grime, and paint if necessary. Be sure cam hubs are tight on their shafts.

9 (3) **Drain mud from collectors.** (See *a* (2) above.)

20 (4) **Check diaphragms for leaks and cracks.** If spare diaphragms are on hand, be sure they are kept under water.

21 (5) **Service unit.** Disassemble unit where necessary to clean, inspect, and lubricate thoroughly. See that all moving parts work freely. Be sure connecting cables are free of knots and are not frayed. If knots or kinks are found in cables, remove them and restring and recalibrate gauge. Do not piece cables because of danger of knots slipping, thus changing gauge setting. Examine stuffing box and repack if leaking. When pendulum rod hangs

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	
						vertically, see that pendulum knife edges bear only on their edges. See that knots in ends of cable are tight.
				13		(6) **Check pressure-pipe lines to diaphragm.** Open pipe lines to gauge diaphragm to see that lines are open, free of incrustation, and that a full stream of water flows through them freely.
						c. **Inspect Mercury Float Types Rate-of-flow Gauges.**
				14		(1) **Test accuracy.** Compute percent error of filter rate-of-flow gauges based on drop-test measurements on filter box. Calculate water volume in filter box for 1 foot of depth above wash-water troughs, allowing for openings into filter gullets and for structural obstructions. Set two hook gauges in filter beneath water surface, so point of one gauge is exactly 1 foot above point of other gauge, and measure volume for which calculation was made. Close filter influent valve and with a stop watch, measure time required for water level to drop this 1 foot. Also record rate of flow indicated during test by rate-of-flow gauge. Calculate percent error by use of the following equations:
						(*a*) Measured rate of flow in gallons per day= $\frac{\text{volume of filter box per foot in gallons} \times 1440 \times 60}{\text{drop-test-time in seconds}}$
						(*b*) Percent error= $\frac{100 \times \text{indicated rate of flow} - \text{measured rate of flow}}{\text{measured rate of flow}}$
						If indicated rate of flow is in error by more than 3 percent, make necessary adjustments.
		10				(2) **Check equipment.** Open equalizing valve so there is no differential pressure in rate-of-flow gauge and then set indicating finger, recording pens, and totalizer to zero position. Check position of stop collars on cables and stops on fingers and recording pens.
					22	(3) **Clean float and mercury.** See *a* (3) above.
					23	(4) **Paint.** Paint interior and exterior of float chamber and other parts of gauge to protect against corrosion.
				15		(5) **Check pressure-pipe lines to float chamber.** Open pipe lines to rate of flow gauge to see that lines are open, free of incrustation, and that a full stream of water flows freely. Clean if necessary.
		11				*d.* **Inspect Pendulum Type Diaphragm.** (1) **Check pendulum units.** Check
		11				rate-of-flow pendulum units with equalized pressures and with setting plate.
		12				(2) **Examine knife edges.** See *b* (2) above.
					24	(3) **Check diaphragms for leaks and cracks.** See *b* (4) above.
					25	(4) **Service unit.** See *b* (5) above.
				16		(5) **Check pressure-pipe lines to diaphragm.** Open pipe lines to gauge diaphragm to see that lines are open, free of incrustation, and that a full stream of water flows freely.
	1					*e.* **Inspect Direct-acting Rate-of-flow Controllers.** (1) **Clean.** Clean rate controller externally, checking to see that water is not leaking around stem through diaphragm pot. Tighten packing or lubricate to stop leakage.

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	
	2					(2) **Check freedom of movement.** Check to see that diaphragm and controller gate move freely between zero differential and maximum differential and between closed and open positions. Lubricate where necessary.
					26	(3) **Disassemble diaphragm pot.** Remove diaphragm pot and disassemble. Remove rubber diaphragm. Paint all exposed metal with several coats of good protective paint. After reassembling, adjust cable tension so controller valve can assume both an open and closed position. Adjust packing so water does not leak around cable stem.
						Note. If water does not form crust or tubercles, this preventive maintenance operation can be scheduled every 3 to 5 years.
					*	(4) **Disassemble controller gate.** Disassemble and service controller gate and mechanism every 3 years. Inspect venturi throat. Apply protective coating where necessary.
	3					*f.* **Inspect Indirect-acting Rate-of-flow Controllers.** (1) **Clean.** Clean outside of rate controller, checking to see that water is not leaking from hydraulic cylinder, controller valve, piping, or pilot valve. Stop leakage by adjusting packing, lubricating, tightening fittings. Be sure all knife edges are clean, free from paint and other foreign matter, and correctly seated.
	4					(2) **Check freedom of movement.** See that piston rod has free vertical travel and does not bind packing. Replace packing if necessary.
					27	(3) **Check pilot valve.** Disassemble pilot valve where necessary to clean, lubricate, and inspect thoroughly. Examine piston of pilot valve. Remove all foreign matter with a cloth. Do not use emery cloth or a file on piston. Be sure piston is free moving. Disconnect and clean pilot-valve piping and strainers. See that sediment is not forced into pilot valve while cleaning. Check diaphragm for leaks and cracks.
					*	(4) **Disassemble controller gate.** Disassemble and service controller gate and mechanism every 3 years. Inspect venturi throat. Apply protective coating where necessary. Inspect and maintain hydraulic cylinders of controllers as for other hydraulic cylinders in plant.
						75. Piping and Valves
		1				**Carefully inspect all piping for leaks.** Check carefully for moisture or leaks at joints. Examine pipe hangers. Replace loose or badly deteriorated hangers. If necessary, paint hangers, piping, and valves to protect metal.

SECTION XVIII

SODIUM ZEOLITE WATER-SOFTENING EQUIPMENT

76. Softener Unit and Brine Regeneration

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	
					10	*a.* **Remove Excess Zeolite Fines.** Remove excess zeolite fines by scraping off about ½ inch to 1 inch of surface.
			2			*b.* **Inspect Water and Brine Distribution Fittings.** Test water and brine distribution fittings and inspect for obstructions, corrosion, and security.
					11	*c.* **Paint Softener Unit.** Brush and clean exterior of unit with wire brush and then paint to protect against corrosion.
	1					*d.* **Check Brine Solution.** Check strength of brine solution delivered to ejector. Use hydrometer to see that it is practically saturated (26° Beaumé). Maintain at least 12-inch depth of undissolved salt.
				7		*e.* **Clean Salt Storage Tank.** Clean salt storage tank at intervals determined by kind of salt used (rock or evaporated), amount of insolubles in it, size of tank, and amounts used in a given time.
				8		*f.* **Paint Brine-measuring Tank.** Clean, wire-brush, and paint both interior and exterior of brine-measuring tank to protect against corrosion.
					12	*g.* **Inspect Ejector.** Inspect and clean ejector. Disassemble and examine for wear and erosion. Clean clogged piping.
				9		*h.* **Inspect for Valve Leaks.** Inspect each individual valve for leaks. Lubricate and repack where necessary. Service multiport operating valves (figs. 57 and 58) as recommended by manufacturer.

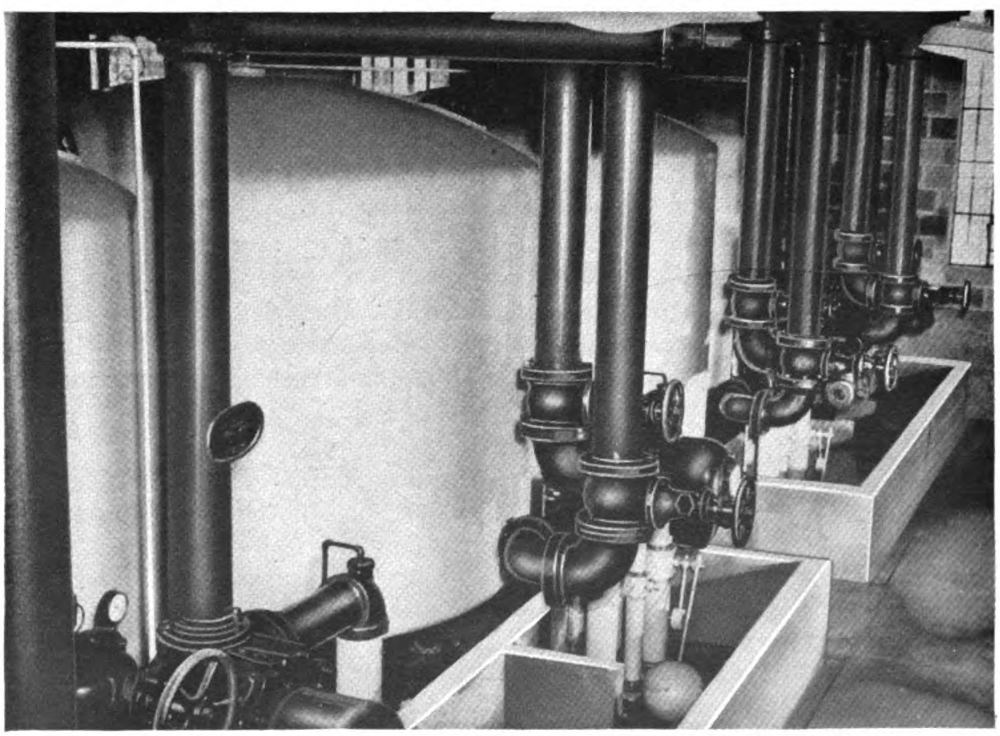


Figure 57. Filters with manually controlled multiport valves.

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY

(1) *Permutit type multiport valve.* Lubricate permutit type multiport valves with CG 1 grease in Alemite pressure gun when hand-operated valves do not turn easily or motor-driven valves chatter.

(*a*) Lubricate multiport valves equipped with Alemite fittings when valve is in either SERVICE or WASH position. When so placed, grease openings are covered by sections of valve body and grease is spread between surface of the two plates. If grease openings are not covered by valve face, lubricant forms blob in open port and washes away when water flow is resumed.

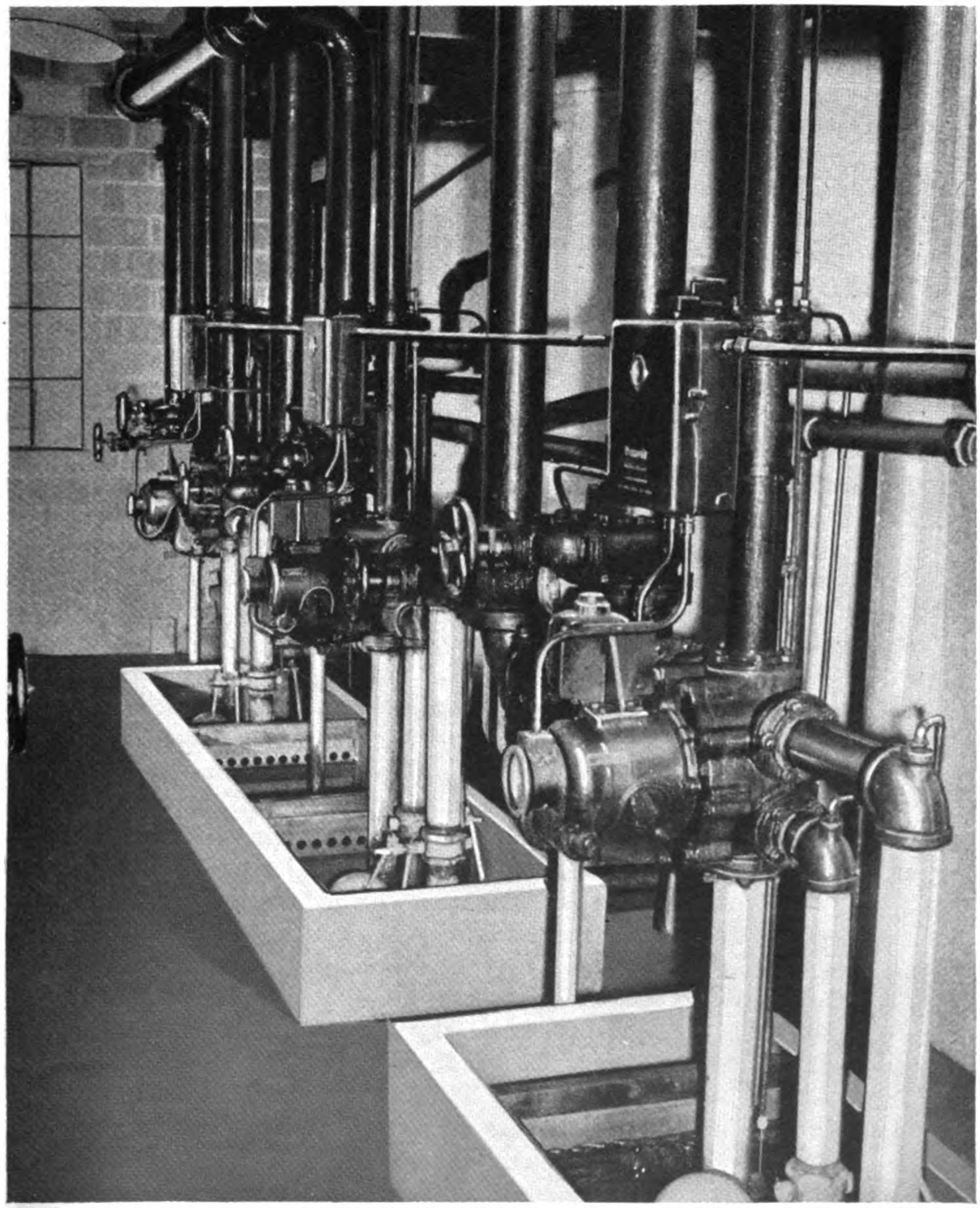


Figure 58. Multiport valves on water softener.

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY

(*b*) Set valve in either SERVICE or WASH position and inject small quantity of lubricant through each fitting. Give valve a half turn from SERVICE to WASH and add more lubricant. Insure complete distribution of the lubricant by giving valve several full turns. It is not necessary to remove softener from service to lubricate, but stopping flow of water may prevent getting grease into water.

(2) *Older type multiport valves.* Lubricate older type multiport valves, which do not have Alemite fittings, by removing cap screws and lifting off bonnet, slide, and facing. Clean flat face of hard-rubber faced casting with clean, dry cloth. Do not use abrasive or scrape surface with a hard instrument. Clean surface on bronze port plate in same way. Spread thin coating of lubricant over flat face of rubber facing and over face of bronze port plate and reassemble valve. After valve is reassembled, let it stand for 1 hour before admitting water.

3 *i.* **Check Service Condition.** Check service condition from tests, operating records, and meter readings.

(1) *Determine softening capacity.* Determine that softening capacity per regeneration is not being exceeded.

(2) *Check flow rates.* Determine that flow rates in softening operation are within equipment's designed limits. High rates may cause packing of bed, high pressure losses, and related trouble. Flow rates for natural zeolites are about 5 gallons per minute per square foot of zeolite surface area and about 6 to 7 gallons for synthetic zeolites.

(3) *Check backwash rates.* Determine that backwashing rates are within equipment's designed limits. Maintaining proper backwash rate is important. If rate is too low, zeolite bed is not properly and entirely loosened and excess fines, dirt, foreign matter, growths, etc., are not washed to the drain. A rate that is too high wastes zeolite. Usual rates for zeolites are about 6 to 8 gallons per square foot of zeolite.

(4) *Check flow rate for rinsing.* Make sure rate of flow for rinsing brine from zeolite is correct. Allow rinse-water volume of about 15 gallons per cubic foot of zeolite for natural zeolites and 20 gallons per cubic foot for synthetic materials. Rinsing time for natural zeolites is 20 to 30 minutes while synthetics need approximately 40 to 60 minutes, both depending on kind of zeolite and grain size. Rinsing at incorrect flow rates wastes water and softening capacity. If excessive rinsing time is required, zeolite bed may be packed or underdrain system defective. Check manufacturer's recommendations for best rinsing rate.

(5) *Check pressure.* Observe difference in pressure-gauge readings on inlet and outlet when operating with full guaranteed flow rate at start and end of softening run. With clear water, these two differential pressures increase during first months of operation and then become practically constant and characteristic of normal operation. Investigates material change from normal. Decrease from normal pressure drop may indicate an improperly closed valve or a channeled zeolite bed; increase may indicate valves not completely open, dirty or improperly washed zeolite bed, loss of zeolite, or clogged underdrain system. However turbid water also causes pressure-differential increases.

(6) *Calculate efficiency.* Calculate equipment efficiency by comparing present softening capacity with capacity when equipment was new. For example, a

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

softener which initially treated 25,000 gallons of 12-grain-hardness water had 300 kilograins softening capacity. If later it softened only 22,000 gallons of 11-grain-hardness water, corresponding to 242 kilograins softening capacity, then its efficiency is 81 percent. A decreasing efficiency indicates dirty or coated zeolite, loss in zeolite, weak brine solution, or improper regeneration.

4 *j*. **Inspect Zeolite Surface.** (1) *Check elevation*. See that zeolite-bed surface is at proper elevation. If level is too low, excess fines, dirt, foreign matter, and growths are not washed from zeolite bed during backwash, causing zeolite deterioration. If level is too high, zeolite is wasted to drain during backwash.

(2) *Check appearance*. Check whether zeolite surface is smooth or hilly, a clue to condition of gravel-bed surface beneath.

(3) *Check for dirt*. Check condition of zeolite surface for dirt, zeolite fines, etc., which may cause channeling through zeolite.

5 *k*. **Maintain Zeolite-bed Depth.** Replace zeolite as needed to maintain original softening capacity.

(1) Maintain zeolite-bed depth by installing in upper head a 2- to 3-inch half-coupling with brass plug. Use coupling to provide a fixed point for measuring distance to zeolite surface and as a means of replacing zeolite, eliminating need for removing manhole cover plate.

(2) Another method of controlling zeolite depth is to install one pressure gauge in straight side of shell above zeolite surface and another gauge extending about 6 inches below zeolite surface. Upper ends of both gauges are set at same level. A pressure differential indicates that zeolite level is between both points of connection.

(3) Still another method is extending small pipes with pressure gauges attached down to and below zeolite surface from manhole cover plate.

* *l*. **Inspect Interior of Underdrain.** Inspect manifold-type underdrain system carefully; merely noting that water flows from strainer heads does not always reveal clogged laterals.

(1) Physically remove several laterals chosen at random and investigate them. If they are clogged, assume that all are clogged and remove all for cleaning or replacement. If inspected laterals are substantially free of obstruction, need for removing the rest of them is questionable. Clogged laterals can be cleared of obstructions mechanically or, occasionally, by using inhibited muriatic acid. Every third year, remove all zeolite and gravel, inspect and repair underdrain systems, clean and paint where necessary, and then replace zeolite and gravel.

(2) Condition of underdrains can also be determined by noting water-pressure drop across underdrain system with full backwash-water flow rate leaving through manhole. If drop is more than at time of installation, laterals and strainer nozzles may be clogged. If pressure drop is less, some nozzles may be out of place or severe corrosion may exist.

(3) Remove plate type underdrain distributors completely, inspect them, paint, and carefully replace them, keeping clearance space between plate and lower head the same throughout the entire periphery.

* *m*. **Replace Zeolite.** Determine necessity of replacing old zeolite with new by inspection, by results of service-condition check (*i* above) by checking equipment efficiency, and by noting causes of efficiency drop.

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY
			6		

n. **Inspect Gravel.** Determine condition of supporting gravel surface by probing through zeolite with small rod to locate hills and depressions, shifting of gravel, and so on. See that surface is level, with tolerance of 4 to 6 inches between maximum and minimum measurements.

(1) *Check gravel bed.* Gravel supports and retains zeolite in softener and distributes backwash-water flow evenly to the zeolite. Incorrect operation, usage, or maintenance of equipment causes gravel hills, shifting of gravel bed, and mud balls, resulting in inefficiency and trouble. To correct such difficulties, remove zeolite and gravel with buckets and wash, regrade, and replace. If shifted gravel and hills are not too large, gravel surface may be leveled by shifting gravel with a rake extended down through suspended zeolite to gravel while zeolite is being backwashed and water is being passed out through manhole. If zeolite is being lost into softened-water lines, remove, regrade, and replace zeolite and gravel.

(2) *Reusing gravel.* New gravel is usually cheaper than cost of washing and regrading old material. If new gravel is installed, use lime-free gravel and not ordinary river gravel so softened water will not pick up hardness from gravel. If old gravel is to be reused, remove any zeolite attached to gravel by placing small quantities of old gravel on a fly screen and spraying with water, causing zeolite to pass through screen. Regrade all gravel according to the three or four sizes of original specifications.

(3) *Replace.* Replace gravel carefully to avoid repeating the process needlessly. In making replacement, place largest size gravel next to strainer system, and level. Control level by drawing chalk ring inside of shell at proper height or by adding just enough water to indicate low spots. Place next smaller size gravel in softener shell. To avoid digging cavities in first layer, raise water level about 6 inches above first course, breaking the fall of second course of gravel. Level second layer as above and repeat the process for remaining layers. Before replacing zeolite, raise water level 12 or 15 inches above last gravel layer to break fall of the zeolite.

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

SECTION XIX
RECARBONATION EQUIPMENT

77. Maintenance Procedure

Production of carbon dioxide from the combustion of gases when burning coke, coal, oil, or gas requires maintenance on burner, combustion chamber, gas scrubber or washer, gas drier, compressor or blower to deliver gas to water, and gas-diffuser grid system, including interconnecting piping and gas traps. Scheduled maintenance is materially affected by type of fuel burned, extent of impurities, effectiveness of scrubber and drier, and materials of construction. Operating experience must govern choice of procedures to be included on field cards at a particular installation. For maintenance of compressor or blower, consult manufacturer's instructions.

1 *a.* **Inspect Operation.** Check compressor, sprays, burners, traps, gauges, and other equipment for proper operation.

2 *b.* **Inspect Drier and Scrubber.** Inspect material in drier, making necessary changes in operation of materials. Adjust sprays if necessary. Clean out connecting piping if necessary.

3 *c.* **Clean Traps.** Inspect and clean gas traps.

4 *d.* **Inspect for Deterioration.** Inspect all equipment internally and externally for corrosion and deterioration. Paint, cover with protective coatings, and repair as necessary.

SECTION XX
AERATION EQUIPMENT

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	
						78. Spray-nozzle Type Aerators
	2					*a.* **Inspect and Clean Spray Nozzles.** Examine each spray nozzle for proper functioning. Clean nozzle of debris where necessary. Do not use pipe wrenches on nozzle tip.
			5			*b.* **Clean and Inspect Pipe and Manifolds.** Remove caps from manifolds and clean out sediment and dirt as required. Examine joints for leaks. Inspect piping supports or piers.
					10	*c.* **Repair Spray Fence.** Spray fences are usually built of wood. Paint and repair as reqired.
						79. Cascade or Step Aerators
	3					*a.* **Inspect for Algae.** Examine aerator surfaces carefully for algae, objectionable growths, unsightly stains. Clean where necessary, scrubbing and treating with copper sulphate and chlorine.
					11	*b.* **Repair.** Make necessary repairs and replacements to aerator surfaces.
						80. Tray and Splash-pan Aerators
	4					*a.* **Inspect for Algae.** See paragraph 79*a*.
				6		*b.* **Repair and Clean.** Make necessary repairs and replacements to aerator surfaces. Remove trays if necessary for proper cleaning or repairs. Reinforce supports and construction to guard against ice damage.
				7		*c.* **Inspect Coke.** On coke-tray aerators, examine coke for algae, microscopic growths, and deterioriation. If cleaning is not effective, replace coke.
				8		*d.* **Repair Screens and Inclosures.** Make necessary repairs to any screens or inclosures.
						81. Diffuser Aerators
1						*a.* **Check Clogging of Diffuser.** The best sign of obstruction in diffuser structure is need of increased compressor or blower pressure to supply a given quantity of air. Less conclusive is a visual examination of aeration tanks which also discloses nonuniform diffusion due to a partially clogged condition. Diffusers may become clogged either on air or liquid side; that is, on the top or bottom of plates and on the outside or inside of tubes. Both kinds of clogging may occur simultaneously.
						(1) *Suspended solids.* Most common type of clogging is caused by interruption of aeration process which allows solids to settle and the water content to filter through the diffusers into the air duct. Most solids in suspension are intercepted at the diffuser surface. However, some solids, depending on pore size, enter the top ⅛ to $\frac{3}{16}$ inch of the structure and when aeration is resumed these particles are not all blown out of the structure and cumulative clogging results. Furthermore, some of the extremely fine solids which filter completely through the structure into the air duct may not be forced back through the diffuser when aeration is resumed, making additional clogging on the air

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY

side possible. Maintaining continuous air delivery is the positive way to eliminate this trouble.

Not less than 1 cubic foot of air per minute should be discharged per square foot of diffuser area; higher discharge rates give even better results.

(2) *Underside clogging.* Air which contains a high percentage of soot, oil, pipe rust, or other impurities is a major source of clogging on underside of diffuser plates or inside diffuser tubes. Maintaining effective air filters, care in locating the air intake, and use of noncorrosive air pipe are obvious preventives.

9 *b.* **Inspect and Clean Air Diffusers.** Drain air diffusers and inspect for joint leaks, broken diffusers, and other deterioration. If operation and checks indicate clogging, clean diffuser tubes.

(1) *Cleaning air side.* When soot from air or oil from filters and blowers have clogged diffusers on the air side, remove them and burn the carbon off in a kiln or furnace. If clogging is caused by iron oxide from pipes or holders, clean plates by treating with 30 percent solution of hydrochloric acid.

(2) *Cleaning water side.* Use oxidizing acids to clean diffusers clogged with organic solids on water side. If plates can be removed easily, pickle them in 50 percent nitric acid. If they are grouted in place with portland cement mortar, nitric acid is unsatisfactory because it attacks the mortar; a mixture of sulfuric and chromic acid (1 gm sodium dichromate per 50 cc concentrated sulfuric) is recommended instead. Apply one-quarter cup of acid per plate and repeat treatment 1 day later. Chlorine introduced into the air line is also effective.

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

SECTION XXI
METERING DEVICES AND RECORDERS

82. Registers, Indicators, and Recorders

The registers, indicators, and recorders whose maintenance is outlined below measure volume, pressure, and temperature.

4 *a.* **Clean, Oil, and Check Setting.** Examine mechanism, clean, and oil shaft and pivot bearings, using OCW oil sparingly. If necessary, clean with lint-free cloth dampened with carbon tetrachloride. Check instrument setting on zero or other reference point and check relative settings of recording pens, indicator hand, and totalizer. If relative settings do not agree, refer to manufacturer's instruction manual for detailed adjustments that can be made by operator. Do not oil or repair electric clocks locally.

1 *b.* **Service Air-relay Units.** Flush liquid side of air-relay units. Drain air side. If much water is present, remove cover and examine diaphragms for punctures or cracks. Be careful not to bend needle-valve stem when replacing diaphragms. Examine air-input orifice and remove foreign matter. Blow out moisture traps.

3 *c.* **Examine Pulley Shaft, Cam Cycle, and Counter.** Examine pulley shaft to be sure it moves freely. Check cam cycle on F1–Watch and Chronoflow instruments for correct time interval. When cam is stationary, fill oil trough with OCW to 1/16 inch from top. See that clock on type M instruments operates correctly.

7 *d.* **Check Calibration.** Check instrument calibration by comparing level indication against known level or by comparing recorded or indicated flow against volumetric displacement on a basin or elevated tank. Where indication is more than 3 percent in error, make necessary adjustments.

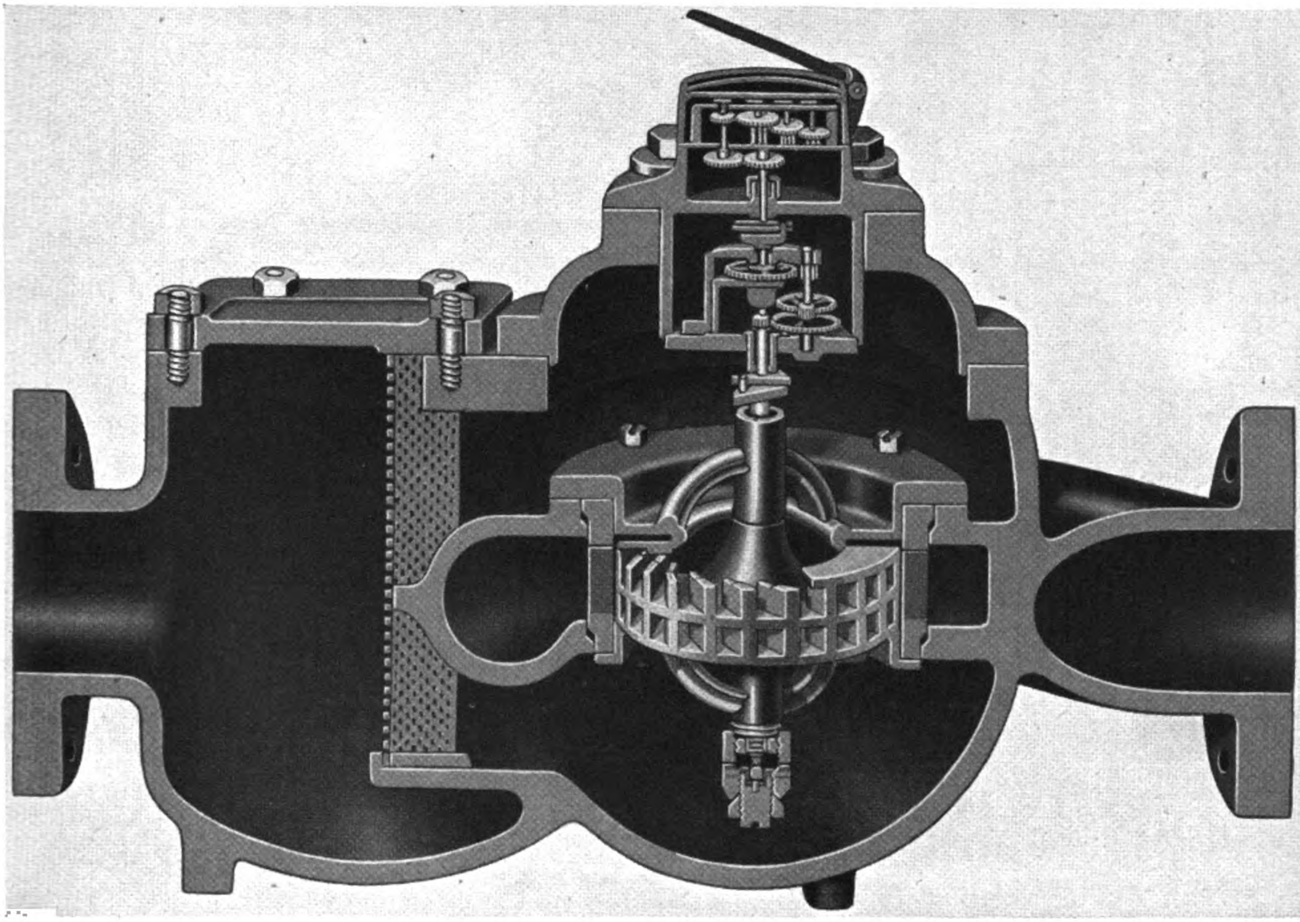
8 *e.* **Check Mercury Wells.** Inspect mercury wells for possible mercury loss. Replace and clean mercury if necessary. Clean mercury wells. Paint to protect against corrosion if necessary.

83. Venturi Tubes

9 **Inspect interior of venturi tubes.** If tubes have inspection plate or plates, examine throat and converging sections for tuberculation, corrosion, or other deterioration. If tube joints are flanged and have gaskets, see that gaskets do not protrude into interior of tube. Flush and clean annular chambers at throat and inlet. Flush connecting piping to instrument. Purge annular chambers and connecting piping of air. Examine pressure piping for leaks. (See fig. 59.)

84. Orifices and Insert Type Flow Nozzles

10 **Inspect orifice plate.** Loosen bolts holding orifice plate in position and withdraw plate. Clean plate and dress off any roughness of orifice throat with fine emery cloth. Flush small piping connected to main piping. Flush out sediment traps. Examine instrument piping for leaks.



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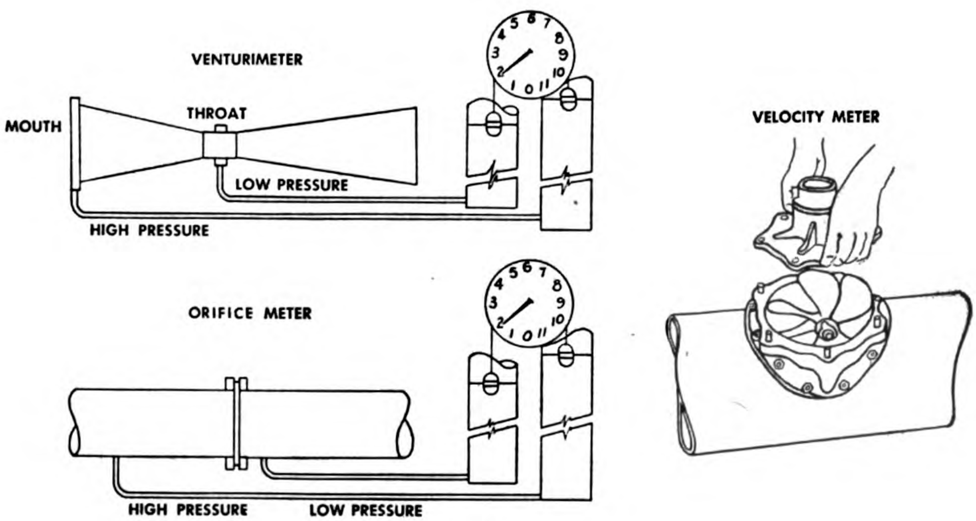

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Figure 59. Meter types.

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DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

85. Weirs

2 *a.* **Clean Weirs.** See that weir edges or notches are clean and free of any material that would interfere with accuracy.

5 *b.* **Check Breather Pipes.** Examine weirs installed in a flume and equipped with breather pipes to see that breather pipes are open. Check frequently in winter to see that frost has not blocked openings.

11 *c.* **Check Level.** Drain weir and check that water level breaks evenly over length of weir as water recedes. Check weir for tuberculation and general deterioration.

86. Water-level Gauges

Drain float pipes in water-level gauges. Examine the interior and remove any tubercles. Flush out with hose and fill with clean water. Examine floats and replace if waterlogged. Examine cable. If worn or frayed remove causes of fraying, such as rubbing on guide pulleys, and replace cable. Inspect guide pulleys and oil the bearings to insure free rotation. Check proper alignment.

87. Pressure Gauges

13 **Remove pressure gauges and test accuracy.** Use a dead weight or similar tester. Reset hand or adjust lever motion when necessary.

88. Disk, Compound, and Turbine Liquid Water Meters

14 *a.* **Check Installation.** See that liquid water meter is horizontal, that it operates under back pressure, and that it is not located on suction line of a pump.

6 *b.* **Check Service Conditions.** See that meter operates at rates of flow, pressure, and temperature within limits of its design. Overloading a meter accelerates wear, especially on disk type meters where high velocity may break disk. Registration accuracy cannot be obtained at rates lower than those specified. To insure proper operation of a liquid meter, keep all operating conditions within limits for which instrument was designed.

* *c.* **Clean and Inspect for Worn Parts.** Examine meter internally, clean, and inspect for worn parts, following manufacturer's instruction for disassembling. Meter registration may be impaired by sediment in interior or by wear of moving parts through long, constant service. Clean and inspect according to the following schedule:

Size	*Registration*	*Service*	*Size*	*Registration*	*Service*
⅝	100,000 cu ft	10 yr	2	1,000,000 cu ft	4 yr
¾	200,000 cu ft	8 yr	3	2,000,000 cu ft	4 yr
1	300,000 cu ft	6 yr	4	5,000,000 cu ft	4 yr
1½	500,000 cu ft	4 yr	6	10,000,000 cu ft	4 yr

15 *d.* **Prevent from Freezing.** One month before freezing weather, inspect housing condition of each meter. See that meter is protected from exposure to below-freezing temperatures.

16 *e.* **Check Hot-water Damage.** Cold-water meters contain hard-rubber parts which are damaged by temperatures above 120° F. Replace all rubber parts in meters suffering hot-water damage, usually caused by generation of steam in improperly operated water heater which backs hot water into meter.

17 *f.* **Clean Pit.**

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

SECTION XXII
DISTRIBUTION SYSTEM

89. Hydrants and Mains

a. GENERAL. Fire hydrants (figs. 60 and 61) are an important part of the post fire-protection system, and must be kept in good working order at all times. Mains must be located and checked periodically for leaks. See TM 5–660 for recommended methods of finding pipes and leaks, cleaning mains, and flushing dead ends.

(1) *Maintenance.* Modern hydrants can be maintained by replacing all working parts and seats through the top of hydrant. Many hydrants require special wrenches or fittings to withdraw the lower parts. Proper tools should be obtained for every type of hydrant on the post.

(2) *Manufacturer's data.* The variety of makes and models of fire hydrants necessitates listing data for each hydrant on the post. Most information is cast on each hydrant, but descriptive matter and operating and repair instructions should be obtained from manufacturers and filed for reference. An indexed looseleaf hydrant record book should be kept showing pertinent physical data including a sketch or drawing referencing each hydrant (see TM 5–660). The master file of hydrant maintenance records can be mounted in this book.

b. INSPECT AND SERVICE. Start inspection at hydrant nearest source of supply. Locate nearest valves on hydrant stub or grid system so they can be shut off if hydrant is found defective during inspection. Carry out valve inspection (par. 98) on same survey. Replace lost caps. Remove *one* hydrant cap and replace with cap fitted with pressure gauge. Open hydrant SLOWLY until wide open.

1 (1) **Check tightness of nozzles.** Inspect at point where nozzles enter hydrant barrel. Calk lead around nozzles when necessary.

2 (2) **Check for leakage in top of hydrant.** If necessary, remove cover, tighten packing gland, or repack.

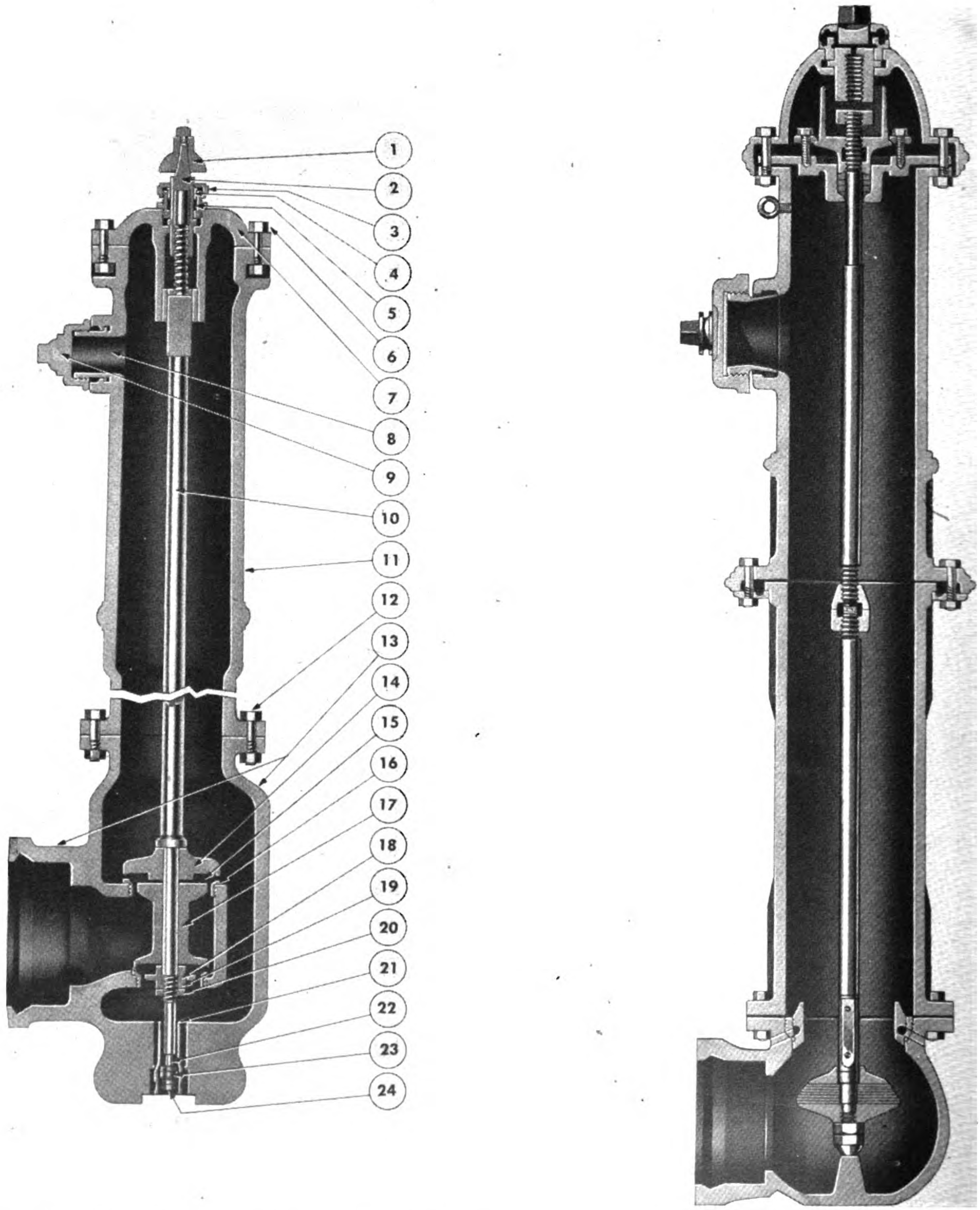
3 (3) **Check for leakage past gaskets under other caps.** Replace defective gaskets.

4 (4) **Check for cracks in barrel.** Order installation of new barrel or hydrant when required.

5 (5) **Look for leakage through drain valve.** Valve should be closed when hydrant is wide open. When necessary, replace drain-valve facing or gasket if water comes up around hydrant when hydrant valve is wide open.

6 (6) **Check static pressure.** Record pressure shown by pressure-gauge reading. Close hydrant valve.

7 (7) **Determine residual pressure.** Remove second hydrant cap, leaving pressure gauge in position; open hydrant valve slowly until wide open; read and record residual pressure on gauge when hydrant is discharging maximum stream. Allow flushing to continue until discharge is clean. CLOSE HYDRANT SLOWLY.



① Top nut.
② Bronze sleeve.
③ Stuffing-box nut.
④ Follower.
⑤ Stuffing box.
⑥ Dome bolts.
⑦ Dome or head.
⑧ Bronze nozzle.
⑨ Nozzle cap.
⑩ Stem.
⑪ Hydrant barrel or standpipe.
⑫ Flange bolts.
⑬ Bottom.
⑭ Upper valve plate.
⑮ Valve rubbers (top and bottom).
⑯ Bronze seats (top and bottom).
⑰ Valve or spool.
⑱ Lower valve plate.
⑲ Bronze nut.
⑳ Bronze locknut.
㉑ Bronze drip cylinder.
㉒ Bronze corrugated drip piece.
㉓ Drip rubber.
㉔ Bronze drip nut.

Figure 60. Balanced-valve and compression-type hydrants.

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

8 (8) **Check tightness of valve and seat.** Watch lowering of water level in hydrant after valve is closed. If level does not drop, listen with ear against hydrant. If noise is heard, main hydrant valve is probably leaking and must be replaced. If water is quiet, drain valve is fouled and must be opened.

9 (9) **Inspect operating nut.** Replace if it has rounded corners caused by improper wrench.

10 (10) **Inspect nozzle threads.** Replace nozzle if they are badly damaged.

11 (11) **Check chains.** If paint has frozen chains tight to caps, chip out paint to free chain. Do not replace lost chains unless required by directives on fireprevention.

12 (12) **Lubricate operating nut.** Remove screw in top of operating nut and apply oil, grease, or graphite grease recommended by manufacturer. If hydrant does not operate freely after lubrication, lubricate packing and thrust collar by oiling joint between nut and collar.

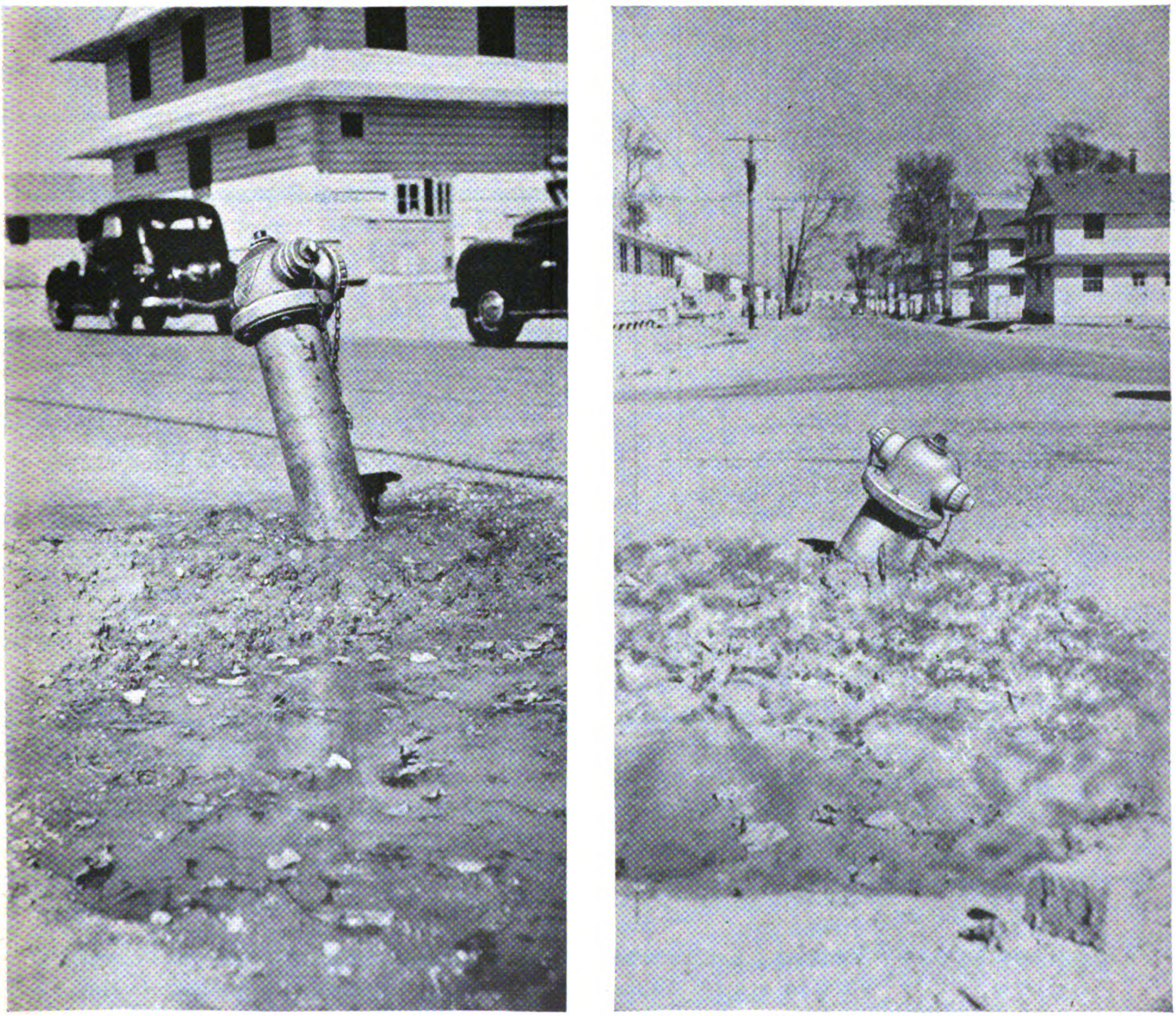


Figure 61. Hydrant installations showing need for maintenance.

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY

13 (13) **Record flow from hydrant.** To determine capacity of flow, use residual-pressure readings shown in table IX which gives flow rates for various-sized nozzles. These rates are approximate, since correction is not made for minor deviations in nozzle diameter. Decidedly low flow indicates that valve mechanism is out of order and must be repaired. Compare results with data from previous tests to see whether there has been any decrease in distribution system carrying capacity. If the concurrent gate-valve inspection does not reveal closed valves, a thorough flow-capacity determination of the system may be required; for procedure, see TM 5–660 (when published). Approval of higher authority should normally be obtained for such a study.

14 (14) **Record errors in location ties.** Complete service record card. On service record card, note those items that are correct and those on which work is performed or on which work orders are processed. If record book shows incorrect reference, correct sketch. For suggested method of filling in inspection and service record, see figure 62.

*

Table IX. Hydrant flow capacity

Residual pressure (lb. per sq. in.)	Discharge (gpm)		
	2 ½-in. nozzle	4-in. nozzle	4 ½-in. nozzle
1	170	430	540
2	240	610	760
3	290	740	930
4	340	850	1, 080
5	380	960	1, 210
6	410	1, 050	1, 320
7	440	1, 130	1, 430
8	480	1, 210	1, 530
9	500	1, 290	1, 620
10	530	1, 360	1, 720
12	580	1, 480	1, 890
14	630	1, 600	2, 030
16	670	1, 710	2, 180
18	710	1, 820	2, 310
20	750	1, 920	2, 430
25	840	2, 150	2, 720
30	920	2, 350	3, 000

c. **Check in Freezing Weather.** In subzero weather inspect hydrants near important structures weekly; inspect other hydrants monthly. Do not flush hydrants on such inspections.

(1) Place operating wrench on nut and turn slightly to make sure it is not frozen. If frozen, thaw by using blow torch on operating nut.

(2) Remove hydrant cap and inspect for ice in barrel by lowering small weight on string. If hydrant contains ice, thaw by one of the following methods:

(*a*) Inject live steam from portable steam thawer.

(*b*) Put in a few aluminum chips mixed with a double amount of caustic soda chips and pour in about a cup of water. The heat which is thus generated

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WD AGO FORM 5-34, 1 JAN 1945

UTILITIES INSPECTION AND SERVICE RECORD

EQUIP. No. W9.10-37 DESCRIPTION HYDRANT AT CROSS AND LINE STREETS

PREVENTIVE MAINTENANCE TO BE DONE BY: FOREMAN OF CONSTR & MAINT - JOHN DOE

ITEM No.	WORK TO BE DONE	REFERENCE	FREQUENCY	TIME
1	CHECK TIGHTNESS OF NOZZLES	896	ANNUAL	OCT
2	CHECK FOR LEAKAGE IN TOP OF HYDRANT	"	"	"
3	CHECK FOR LEAKAGE PAST GASKETS UNDER OTHER CAPS	"	"	"
4	CHECK FOR CRACKS IN BARREL	"	"	"
5	LOOK FOR LEAKAGE THROUGH DRAIN VALVE	"	"	"
6	CHECK STATIC PRESSURE	"	"	"
7	DETERMINE RESIDUAL PRESSURE	"	"	"
8	CHECK TIGHTNESS OF VALVE AND SEAT	"	"	"
9	INSPECT OPERATING NUT	"	"	"
10	INSPECT NOZZLE THREADS	"	"	"
11	CHECK CHAINS	"	"	"
12	LUBRICATE OPERATING NUT	"	"	"
13	RECORD FLOW FROM HYDRANT (REVERSE SIDE)	"	"	"
14	RECORD ERRORS IN LOCATION TIES (REVERSE SIDE)	"	"	"

Schedule Inspection and Service on this side.
Record Inspection and Service on reverse side.

10—43400-1

1

SERVICE RECORD

DATE	WORK DONE	SIGNED	DATE	WORK DONE	SIGNED	DATE	WORK DONE	SIGNED
10/3/45	1,2,3,4,5. OK	J.D.						
"	6-50#. 7-18#	J.D.						
"	8,9,10 OK	J.D.						
"	11 LOOSENED	J.D.						
"	12 OILED	J.D.						
"	13 - 710 GPM	J.D.						
"	14 DISTANCE TO							
	T672 IS 58'	J.D.						
10/6/45	TIE BOOK CHANGED	H.O.H.						

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2

Figure 62. Service record card for hydrant maintenance schedule.

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

will thaw out hydrant barrel in 10 to 20 minutes. Remove hydrant caps to allow generated gas to escape.

(*c*) Build small bonfire around hydrant.

(3) After ice is thawed enough to allow opening hydrant, flush slowly until all ice is melted.

If hydrant barrel does not drain, pump out all water and fill with salt.

90. Elevated Steel Tanks and Ground-storage Tanks

1 *a*. **Check General Condition.** Examine tank for loose scale and leaky seams and rivets.

2 *b*. **Inspect Ladders.** Check for missing connecting bolts, deteriorated lugs and rungs, and any other conditions that would make the ladders unsafe. Be sure to include ladders inside tank and riser in the inspection. Inspect revolving ladder on roof for poor connection at the finial.

3 *c*. **Check Condition of Roof.** See that screens on overflow and other openings are in place and adequate to prevent entrance of birds and other harmful matter. If spider rods under roof are in bad repair, remove them because they are not needed after tank is erected.

4 *d*. **Examine Sway Bracing.** Check for tautness, tightening turnbuckles if necessary. Look for corrosion *under* clevis pins and rod loops because the underside is likely to be in worse condition than the top. Perforate balcony floor of elevated tanks to eliminate standing water. Examine handrail, rods, turnbuckles, clevises, and pins for safety.

5 *e*. **Inspect Structural Forms.** Examine back surfaces of lattice bars and anchor bolts, inside of boxed channel columns, and pockets where batten-plate connections and column bases form pockets for collecting trash and water without proper drainage. Clean and paint these inclosures and fill them with concrete to a proper level, shaped to shed water.

6 *f*. **Examine Bases and Base Plates.** If base holds water, drill 1½-inch hole through channel-boxed section to permit drainage. Remove trash at regular intervals. Grout baseplates with a mixture of sand asphalt to keep water from running under plates. Taper off grout from top edge of plate to concrete pier.

7 *g*. **Inspect Tank or Standtower Foundations.** If any deterioration exists, repair with a cement mix of one part cement and one part sand.

8 *h*. **Check Locks on Roof Hatches.** Make sure hatches are locked at all times. Check condition of altitude valve vault and equipment in vault. Clean and paint all equipment requiring attention.

9 *i*. **Check Tank Lights.** Make sure lights are lit, and check with AAF regarding general visibility of tank from the air.

10 *j*. **Inspect Condition of Paint.** Make sure paint is adequate to protect tank and substructure from corrosion. Empty tank and examine interior paint carefully because corrosion usually occurs from inside. If inspection shows need for it, arrange for withdrawing tank from service to permit repainting. Paint tank interior as often as exterior, since most corrosion starts inside the tank. Paint interior more frequently if water being stored is particularly corrosive. If tank is equipped with cathodic protection (*k* below), paint all parts of tank interior which are not usually covered with water. Arrange for installa-

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

tion of cathodic protection on tanks which cannot be removed from service long enough to permit repainting their interior surfaces.

(1) Apply only one new coat if old paint is in fair condition. Paint bare portions of steel with spot or patch coat before applying finish coat. If surface is generally in bad condition, use a complete primer coat.

(2) Because underwater exposure wears paint severely, care must be exercised in selecting paints for use on tanks. The paint which generally gives best service is red-lead and linseed-oil paint weighing 21 to 24 pounds per gallon, to which small amounts of litharge are added as a hardener. However, this type is not satisfactory for all waters. Where its use has proved unsatisfactory consider using an alternate type. Asphalt paints are suitable in some cases. Coal-tar enamels are generally satisfactory where ice formation is not a factor. The new synthetic resin type paints give good results under many condi tions.

(3) Do not apply a finish coat over red-lead and oil paints. Use the same paint if a second coat is specified, but add a small amount of lampblack to the second coat to make it darker and therefore easier to tell whether first coat has been entirely covered. Graphite paint may be used on exterior surfaces if old paint outside the tank is black or dark green. If the old paint is aluminum or light-colored and in poor condition, two coats may be necessary to insure good appearance. Use red lead or similar suitable primer paint for patch coats. If finish coat is dark, darken red-lead patch coat with lampblack to cover patch areas completely.

(4) Follow safety precautions when painting interiors of closed tanks. Provide adequate ventilation to prevent accumulations of dangerous gases. (See Tentative Recommended Practice – Repainting Elevated Steel Tanks and Water Storage Tanks (with Notes on Repairs), American Water Works Association, 500 Fifth Ave, New York, New York.)

* *k*. **Check Operation of Cathodic-protection Equipment.** This equipment is used to protect towers against corrosion when painting is not practical

(1) While equipment is operating, note and record current flow shown by meters. If current is not flowing, check fuses, electrodes touching tank, ground-wire connection to tank, and immersion of electrodes. If equipment operates at voltages or amperages over those listed on name plate, the rectifier may be damaged. Check polarity and direction of current flow. If connections to rectifier are reversed, rapid damage to tank results.

(2) Check operating records and other data to see whether electrodes are normally covered with water. Because cathodic-protection equipment is effective only below waterline, keep enough water in tank to cover the electrodes. However, unit is not damaged if electrodes are not immersed.

(3) Check condition of electrodes, which deteriorate because of action of current passing from electrodes to water. Replace electrodes so worn that physical failure is imminent. Watch for diminished current flow on ammeter, a sign that electrodes may be failing.

(4) Protect electrodes from ice, which may damage them or tear them from their hangings. If ice formation is a serious problem, turn off current and remove and store electrodes during freezing season. Tank protection continues for 2 to 3 weeks after unit is out of operation. Reinstall electrodes at end of freezing season.

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

(5) Test effectiveness of equipment by one of the following methods:

(*a*) Scrape and polish a spot on the tank wall at a point which is constantly under water. Lower water level every 3 months and check this spot for corrosion.

(*b*) Use No. 6 galvanized steel wire to suspend two polished mild-steel specimens in tank. Attach one suspension wire to tank, and insulate other wire from tank. Corrosion on grounded specimen approximates corrosion on tank; corrosion on insulated specimen approximates tank corrosion without cathodic protection.

11 *l.* **Check Heating Systems for Elevated Tanks.** Potable water storage tanks with small riser pipes and elevated tanks which are used only for fire protection and through which there is no daily water circulation sometimes have heating equipment for use in severe cold.

(1) *Two months* before freezing weather, inspect insulation and frost jacket around riser. Seal all openings to prevent excessive heat loss. Inspect elements of heating system to insure proper functioning through winter season. Clean with wire brush and paint all pipe and equipment showing exterior corrosion.

(2) *One month* before freezing weather, operate heating system at least 8 hours to check condition of elements in operation.

91. Wooden Water Tanks

After wooden tank is erected, made watertight, and has its hoops painted, little maintenance is required as long as the tank is kept full of water.

1 *a.* **Check Service Condition.** Check operating data, level and pressure gauges or other available information to see whether tank is normally filled with water.

2 *b.* **Inspect Tank.** Check water level and structural condition. Look for leaks. If any are found, repair them immediately because wood around leaks deteriorates rapidly. If there are leaks, examine steel hoops and bands for corrosion and replace noticeably corroded bands, particularly those corroded at threaded ends. Structural failure of tanks supported by timber substructures is generally caused by failure of one or more members which were cross-grained or contained hidden defects. Replace or properly reinforce members which develop bowing, curvature, warping, or splitting. Check all timbers for splitting, checking, and dry rot. Inspect lower ends of timber legs for signs of termite activity. Make sure compression members are straight and sway bracing taut. See that all bolted connections are tight.

3 *c.* **Examine Tank Accessories.** Examine ladders, opening covers, gauges, screens, and roof for signs of deterioration. Repair as needed.

* *d.* **Paint Tank.** Painting does not materially lengthen the life of a wooden tank, and should be done, when permitted by directives, only when needed to improve its appearance. However, metal parts must be painted to protect against corrosion.

92. Concrete Water-storage Tanks

2 *a.* **Check General Condition.** Inspect concrete water-storage tanks each spring for watertightness and structural condition. Check all interior and ex-

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	
						terior surfaces for spalling resulting from frost, for exposed reinforcing, and for other structural deterioration. Remove all loose, scaly, or crumbling concrete. Patch with rich cement grout after wetting concrete and painting with portland cement slurry. If tank is in bad condition, repairs may best be done by contract.
				1		*b*. **Check Leakage.** Mark places on tank's exterior where leakage or seepage occurs. When tank is empty, inspect interior to locate cracks, porous concrete, breaks in interior seal membrane, or other points where water is escaping.
						(1) Chip out leaking cracks to ¼-inch width and 1-inch depth. Moisten interior of crack, brush with slurry of portland cement and water, and fill crack with rich cement grout, dry enough to stay in crack without sloughing. After grout hardens, paint with iron waterproofing compound such as No. 7 Western Waterproofing Compound or similar preparation. Cracks may also be filled with grout to which a waterproofing admixture has been added.
						(2) If cracks occur in prestressed structures, contact designing and erecting company for recommendations if guarantee does not cover correction of defects.

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

on diaphragm spring-tension setting one or two turns. Return nut to its exact position after inspection.

7 *c.* **Service Ross Automatic Valve.** When Ross automatic valve (fig. 63) is to be opened, external control shuts off power water and vents chamber K to the atmosphere. Then pressure inside main valve lifts upper piston, raising valve disc from its seat. To close valve, power water is automatically supplied to chamber K by external control valve. Although pressure inside valve may be same as power water pressure, valve closes because lower part of cap cylinder (23) is vented to atmosphere. Equivalent area above upper piston is greater than area below this piston.

(1) Disassemble and inspect. Remove top cap. Withdraw stem for inspection.

(2) Clean valve of all sediment.

(3) Replace worn cup leathers. Leakage occurs through vent below (6) when bottom cup leathers are worn. Worn seat leathers permit leakage through main valve. Leakage past main cup leathers may also indicate improper valve functioning. Leathers may last 4 to 10 years.

8 *d.* **Service Anderson and Golden-Anderson Valves.** Globe-pattern valves (fig. 64) are closed by discharge of water at line pressure through port (1) above sliding piston (2) which forces piston down to its seat. To open, pressure above piston (2) is reduced as pilot valve closes off pressure water and vents port (1) to atmosphere. Line pressure beneath piston (2) forces piston up.

(1) Dismantle valve. Remove valve lid covering piston chamber. Withdraw piston.

(2) Inspect walls of piston and cylinder lines for scoring. Smooth and polish with fine emery cloth.

(3) Inspect leather piston and liner cups and piston seat. Replace if necessary. Leathers may last from 4 to 10 years.

(4) Check for leakage. Keep port (3) open at all times. Leakage here indicates worn cup rings or scored piston or liner surface. Constant leakage from pilot waste line indicates defective pressure valve, which must be reground and replaced. Leakage through main valve indicates worn leather seat rings.

95. Cone-plug Valves

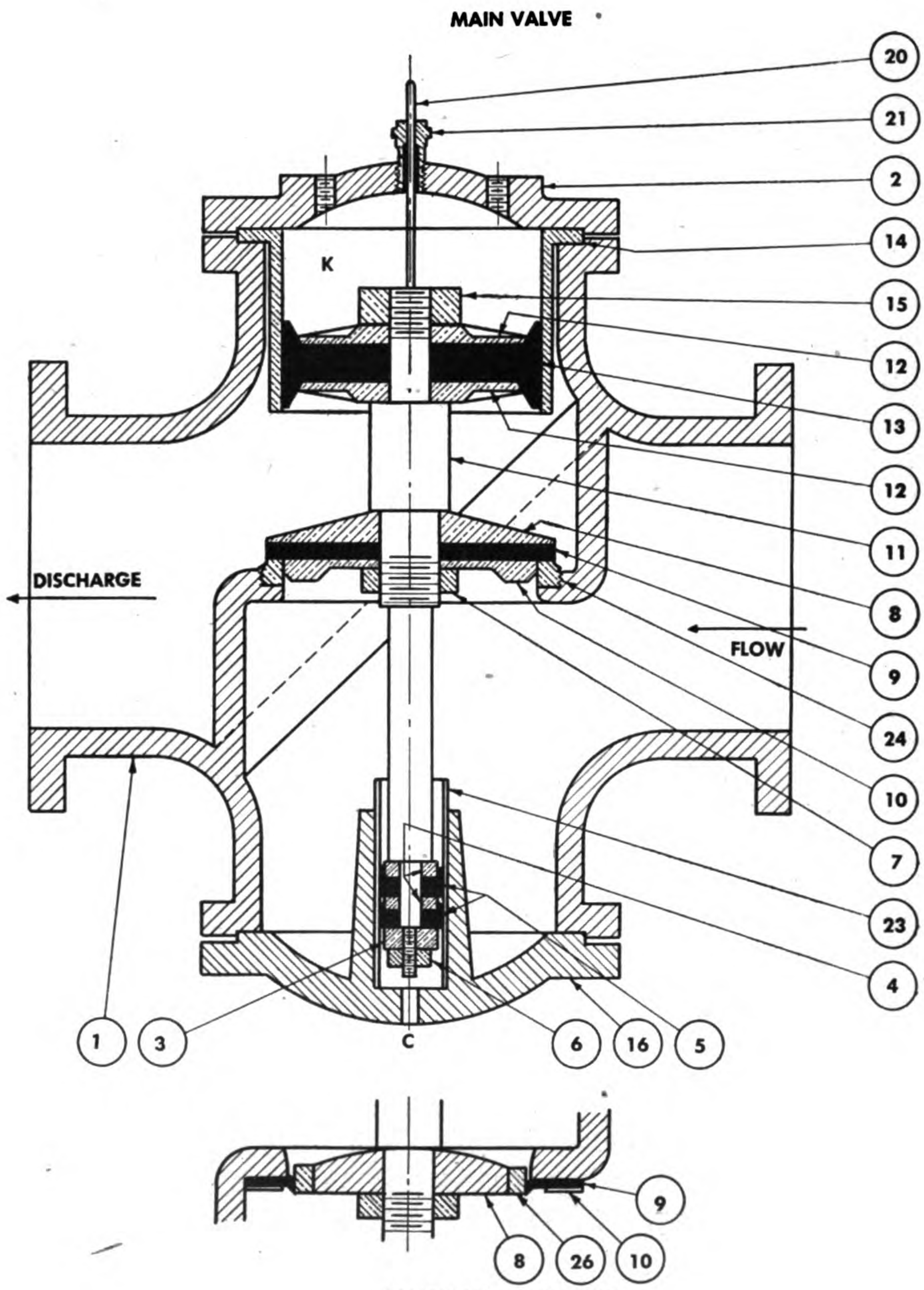
Cone valves with full round way openings are supplied by several manufacturers in 4-inch and larger sizes. The cone plug is seated against the valve body in both open and closed positions. While operating, the plug is lifted off its seat, revolved, and reseated by a hydraulic cylinder which is pilot-actuated or manual. Because of the many kinds of pilot controls used for altitude, check, pressure regulation, and pressure relief, specific operating and maintenance instructions should be obtained from manufacturer for each cone valve in service.

2 *a.* **Lubricate.** Operate each cone valve by uncoupling pilot valve linkage and moving pilot control manually or by changing pilot control setting momentarily.

(1) Grease or oil metal-to-metal contacts in pilot mechanism.

(2) Oil packing glands.

(3) Grease or oil all parts of seating and rotating mechanism.



LONGITUDINAL SECTION
(SHOWING SLIDING SEAT DISC)

① Valve shell.	⑫ Plate.
② Top cap.	⑬ Main cup leather.
③ Bottom stem guide nut.	⑭ Main bushing.
④ Bottom cup follower.	⑮ Top nut.
⑤ Bottom piston-cup leather.	⑯ Bottom cap.
⑥ Bottom stem locknut.	⑳ Indicator rod.
⑦ Nut.	㉑ Indicator stuffing box.
⑧ Seat disk.	㉓ Cap cylinder.
⑨ Seat leather.	㉔ Seat ring.
⑩ Seat-leather support.	㉖ Disk ring.
⑪ Stem.	

Figure 63. Ross main valve.

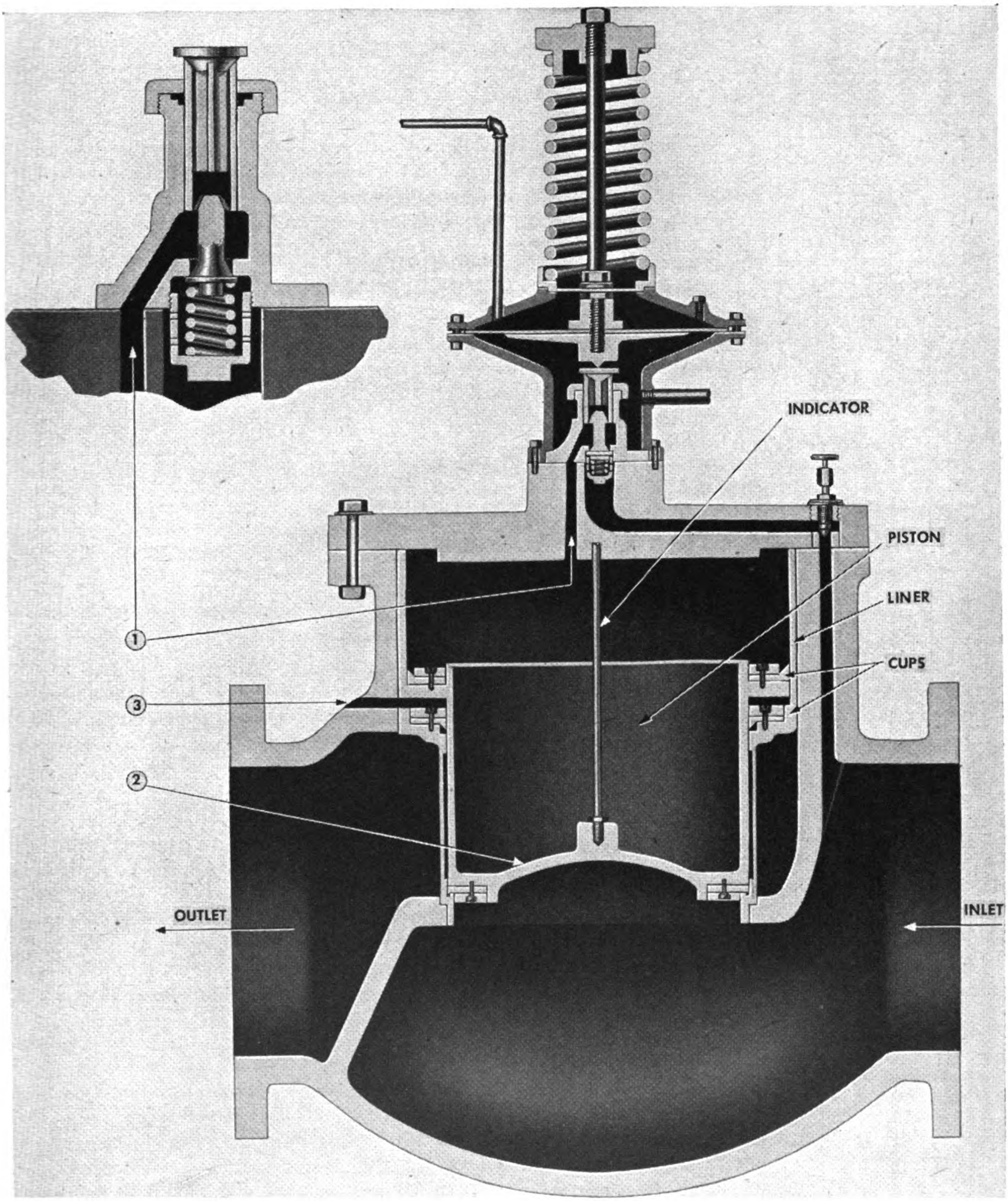


Figure 64. Globe-pattern single-acting automatic valve.

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

9 *b*. **Dismantle and Service.** Remove all corrosion on plug or valve body. Clean with wire brush and paint inside and out with two coats of good corrosion-resistant paint. Corrosion or tuberculation on plug or inside valve body prevents tight seating and causes wire-drawing and seat corrosion.

96. Hydraulic-cylinder-operated Valves

3 *a*. **Inspect and Lubricate.** Check hydraulic cylinder while valve is put through an operating cycle.

(1) Oil packing around piston rod and telltale tod. Tighten if leakage is found.

(2) Replace packing when normal pressure on gland does not stop leak.

(3) Check waste-line discharge. When waste line continually discharges water in either open or closed position, dismantle cylinder and check piston-cup leathers for wear.

10 *b*. **Dismantle Cylinder and Piston.** (1) Remove scoring of cylinder liners with fine emery cloth.

(2) Check condition of cup leathers.

(3) Check condition of piston and telltale rods, especially where they contact packing. Polish out any scoring.

(4) Clean cylinder heads and piston surfaces of all corrosion. Apply two coats of protective paint to all iron surfaces.

97. Valve-pilot Controls

Valves operated by hydraulic cylinders, automatic valves with internal cylinders, or equivalent mechanisms are usually actuated by manual, diaphragm, or electric-operated pilot valves. Observe pilot control during one or more cycles to check for proper operation.

4 *a*. **Lubricate and Check Leakage.** (1) Oil pins and linkage.

(2) Grease exposed threads on adjustment rods.

(3) Oil packing glands. Remove corrosion which might cause friction.

(4) Check for leakage past valve seats or through ruptured diaphragm. Repair where necessary.

11 *b*. **Dismantle and Inspect Pilot-valve Assembly.** (1) Grind or replace valve seats when seats show pitting or leakage.

(2) Clean all strainers in control-piping lines.

(3) Check diaphragms. Look for signs of possible failure such as cracking or separation of fabric layers.

98. Gate Valves (Buried)

a. General. Distribution system gate valves are generally known as non-rising stem, inside screw, solid wedge, or double disk gate valves. They are usually equipped with 2-inch-square operating nuts and, although sometimes located in vaults or manholes, are usually covered and protected with adjustable height, cast-iron roadway boxes about 6 inches in diameter. To make sure each valve is instantly serviceable, periodic inspection and prompt repair are required. There are three common sources of trouble:

(1) Valves cannot be located in an emergency.

(2) They cannot be operated because maintenance has not been performed.

(3) They are covered up, obstructed, pushed sideways by road graders, or filled with foreign matter.

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WD AGO FORM 5-34
1 JAN 1945

UTILITIES INSPECTION AND SERVICE RECORD

EQUIP. No. W 9.20-67 | DESCRIPTION 16" VALVE ON F STREET N W OF 30" MAIN IN F ROAD

PREVENTIVE MAINTENANCE TO BE DONE BY: FOREMAN OF CONSTR & MAINT - JOHN DOE

ITEM No.	WORK TO BE DONE	REFERENCE	FREQUENCY	TIME
1	RECORD ERRORS IN LOCATION TIES	98c	ANNUAL	OCT
2	NOTE WHETHER VALVE IS FOUND OPEN OR CLOSED	"	"	"
3	CHECK OPERATION	"	"	"
4	CHECK AND LUBRICATE PACKING	"	"	"
5	CHECK FOR BENT STEM	"	"	"
6	CHECK OPERATING NUT	"	"	"
7	CHECK AND LUBRICATE GEARS	"	"	"
8	CHECK BYPASS	"	"	"
9	CHECK CONDITION OF BOX OR VAULT	"	"	"

Schedule Inspection and Service on this side.
Record Inspection and Service on reverse side.

16—43408-1

1

SERVICE RECORD

DATE	WORK DONE	SIGNED	DATE	WORK DONE	SIGNED	DATE	WORK DONE	SIGNED
10/7/45	1-OK 2-OPEN	J.D.						
"	3-TURNS HARD	J.D.						
"	4-OILED	J.D.						
"	5-STEM BENT	J.D.						
"	6-OK	J.D.						
"	7-8-NOT APPLY	J.D.						
"	9-REPLACED COVER	J.D.						
10/8/45	WO 778 FOR							
	REPLACING STEM	J.D.						
10/10/45	5-REPLACED	H.O.H.						
"	3-OK	H.O.H.						

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Figure 65. Service record card for valve maintenance schedule.

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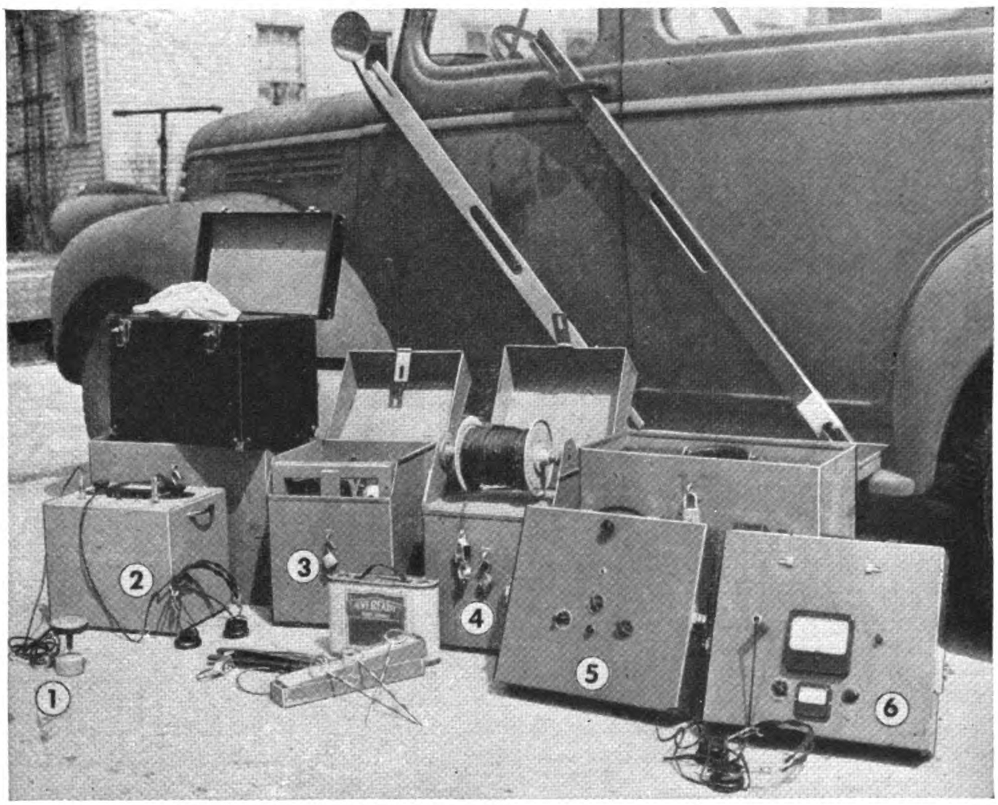
DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY

b. Finding Valves. Keep pertinent gate-valve physical data records in an indexed looseleaf valve book (see TM 5–660). Include a sketch or drawing for referencing each valve on each valve sheet, showing location of steel, concrete, or wood reference stakes where necessary. Mount master file of valve maintenance record cards in valve book (fig. 65). Make copy of book available to maintenance crew. To assist in locating lost valves, carry a dip needle or miner's compass in service truck. A mine locator can also be used. Service command water waste survey engineers are available in locating valves, pipes, and leaks as well as for training post personnel in finding valves (fig. 66).

1 *c.* Inspect and Service Valves. (1) **Record errors in location ties.** Record errors in location tie-ins on reverse side of service record card for transfer to master file and correction in valve book. Be sure notation is made of reference points or monuments which have been removed or relocated.

2 (2) **Note whether valve is found open or closed.**

3 (3) **Check operation.** Where possible check operation by closing valves completely and then opening them. If post requirements would be affected by completely closing valves such as those on primary transmission mains or dead-end mains, do not close them completely unless specific arrangements are made to meet post needs from another source. To inspect, close such valves partially, then open them.



① Microphone.
② Stand-by leak detector powered by dry cells.
③ Pipe energizer, for connecting to exposed portion of pipe and ground.
④ Pipe energizer, including 500 feet of cable. Used to energize pipe with two exposed points.
⑤ Transmitter of pipe finder for cable or valve exploration.
⑥ Receiver of pipe finder.

Figure 66. Service command or division engineer pipe-location and leak-detecting apparatus.

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

4 (4) **Check and lubricate packing.** Dry packing is shown by difficult operation at all points of valve movement. To moisten and lubricate dry packing, pour half-and-half mixture of kerosene and lubricating oil down a ½-inch pipe, bent at bottom to touch stem below operating nut. If packing leaks, dig up valve and tighten packing. If necessary, replace packing, opening valve as much as possible and pulling stem shoulder tight against bonnet to prevent excessive leakage during the operation.

5 (5) **Check for bent stem.** Bent stems allow comparatively free operation when valve is nearly open or closed but cause considerable binding in middle portion of travel. Replace stem without shutting down other valves. Close valve tightly. Remove stuffing-box assembly and unscrew stem from stem nut. Insert new stem, reassemble stuffing box, and repack valve.

(*a*) Broken or stripped stems or stem nuts permit unlimited turning of valve stem. If found, remove pressure from main, open valve, and repair. If new parts are not available, remove gate and stem and drive tapered softwood plug into stem opening from inside of bonnet. Replace working parts after repair parts have been obtained.

(*b*) Injury to valve stems usually results from using too much force when trying to close gates which are kept from seating by foreign matter, scale, or corrosion under the seat in the lower part of the body. To prevent this, open valve a few turns after first closing it, and admit a good flow of water under gate to wash out loose material. After repeating operation four or five times, a reasonably tight closure can usually be made.

6 (6) **Check operating nut.** Replace missing or badly chewed operating nuts.

7 (7) **Check and lubricate gears.** Observe and correct any bad operating condition. Grease gears. (See par. 7 and table VI.)

8 (8) **Check bypass.** Note whether bypass is open or closed and whether small valve is operating satisfactorily. If a globe valve needs repairs, follow procedure given in paragraph 99f.

9 (9) **Check condition of box or vault.** Adjust box or vault if buried or protruding. Reset if box is too close to stem. Check cover and replace if missing or broken. Loosen wedged, tarred, or grouted-in cover. If vault or manhole is installed, see paragraph 11 for maintenance instructions. Clean box of debris, sand, and dirt above packing gland.

99. Gate Valves (Not Buried)

Most common maintenance required by unburied gate valves (fig. 67) is oiling, tightening, or replacing stem stuffing-box packing.

15 *a.* **Oil Packing.** To eliminate excessive friction between valve stem and packing, lubricate packing with a few drops of graphite bearing oil, use GG grease on packing which always requires lubrication. Stop leakage by tightening stuffing-box nuts, forcing packing gland tightly against packing.

* *b.* **Replace Packing.** Modern gate valves can be repacked without removing them from service. Before repacking, open valve wide. This prevents excessive leakage when packing or entire stuffing box is removed by drawing stem collar tightly against bonnet on a nonrising stem valve, and tightly against bonnet bushing on a rising-stem valve.

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

(1) *Clean stuffing box.* Remove all old packing from inside of stuffing box with a packing hook or a rat tail file with bent end. Clean valve stem of all adhering particles and polish it with fine emery cloth.

(2) *Insert packing.* Insert new split-ring packing in stuffing box and tamp it into place with packing gland. Stagger ring splits. After stuffing box is filled place a few drops of oil on stem, assemble gland, and tighten it down on packing.

11 *c.* **Operate Valve.** Operate inactive gate valves to prevent sticking.

16 *d.* **Lubricate Gearing.** Lubricate gate valves as recommended by manufacturer. Lubricate thoroughly any gearing in large gate valves. Wash open gears with kerosene and lubricate with WB 2 grease or NS 5190 oil.

12 *e.* **Lubricate Rising-stem Threads.** Clean threads on rising-stem gate valves and lubricate with WB 2 grease.

* *f.* **Reface Leaky Gate Valve Seats.** If gate valve seats leak, reface them immediately, using the method discussed below and illustrated in figure 68. A solid wedge disk valve is used for illustration, but the general method also applies to other types of repairable gate valves. Proceed as follows:

(1) Remove bonnet and clean and examine disk and body thoroughly (fig. 68 (1)). Carefully determine extent of damage to body rings and disk. If corrosion has caused excessive pitting or eating away of metal, as in guide ribs in body, repair may be impractical.

(2) Check and service all parts of valve completely. Remove stem from bonnet and examine for scoring and pitting where packing makes contact. Polish lightly with fine emery cloth to put stem in good condition (fig. 68 (2)). Use soft jaws if stem is put in vise.

(3) Remove all old packing and clean out stuffing box (fig. 68 (3)); clean all dirt, scale, and corrosion from inside of valve bonnet and other parts.

(4) Do not salvage an old gasket. Remove it completely (fig. 68 (4)) and replace with one of proper quality and size.

(5) After cleaning and examining all parts, determine whether valve can be repaired by removing cuts from disk and body-seat faces or by replacement

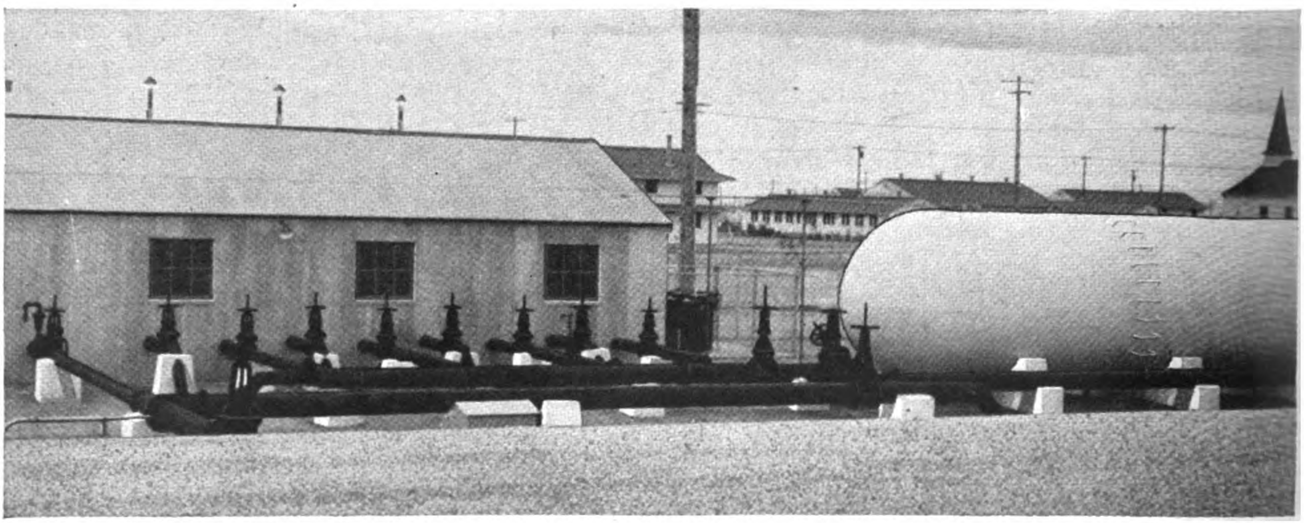


Figure 67. In installations of this type, the large number of valves used makes proper valve maintenance extremely important.

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

of body seats. If repair can be made, set disk in vise with face leveled, wrap fine emery cloth around a flat tool, and rub or lap off entire bearing surfaces on both sides to a smooth, even finish (fig. 68 (5)). Remove as little metal as possible.

(6) Repair cuts and scratches on body rings by lapping (fig. 68 (6)). Use emery block small enough to permit rubbing all around rings. Work carefully to avoid removing so much metal that disk will seat too low. After seating surfaces of disk and body rings are properly lapped in, coat faces of disk with Prussian blue and drop disk in body to check contact. When good, continuous contact is obtained, valve is tight and ready for assembly. When assembling, insert stem in bonnet, install new packing, assemble other parts, attach disk to stem, and place assembly in body. Raise disk to prevent contact with seats so bonnet can be properly seated on the body before tightening the joint.

(7) Test repaired valve before putting it back in line to insure that repairs have been properly made.

(8) If leaky gate valve seats cannot be refaced, remove and replace seat rings with a power lathe. Chuck up body with rings vertical to arbor and use a strong steel bar across ring lugs to unscrew them. They can be removed by hand with a diamond point-chisel if care is taken to avoid harming threads. Drive new rings home tightly. Use a wrench on a steel bar across lugs when putting ring in by hand. Always coat threads with a good lubricant before putting them in. Lap in rings to fit disks perfectly.

100. Merco-Nordstrom Plug Valves

* *a.* **Adjust Gland.** The adjustable gland holds plug against its seat in body, and acts through compressible packing which functions as a thrust cushion. Keep gland tight enough at all times to hold plug in contact with its seat. If this is not done, lubricant system cannot function properly and solid particles may enter between the body and plug and cause damage.

10 *b.* **Lubricate all Valves.** Apply lubricant by removing lubricant screw and inserting stick of LV plug valve lubricant for usual temperature conditions. Check valve fitting within shank to prevent line pressure from blowing out when lubricant screw is removed. Inject lubricant into valve by turning screw down as needed to keep valve in proper operating condition. If lubrication has been neglected, several sticks of lubricant may be necessary before system is refilled to operating condition. Be sure to lubricate valves which are not used often to insure that they are always in operating condition. Leave lubricant chamber nearly full so extra supply is available by turning down on the screw. Use lubricant regularly to increase valve efficiency and service, promote easy operation, reduce wear and corrosion, and seal valve against internal leakage.

13 *c.* **Lubricate Valves on ACF Plug Valve Type.** To protect them against rust, all stock valves are filled with an assembly lubricant which is extremely soft, white, insoluble in water, and soluble in dry-cleaning solvent. Before placing valve in the line, lubricate with stick LV plug valve lubricant, which readily displaces assembly lubricant. This lubricant can also be used in a grease gun with gasoline as a solvent.

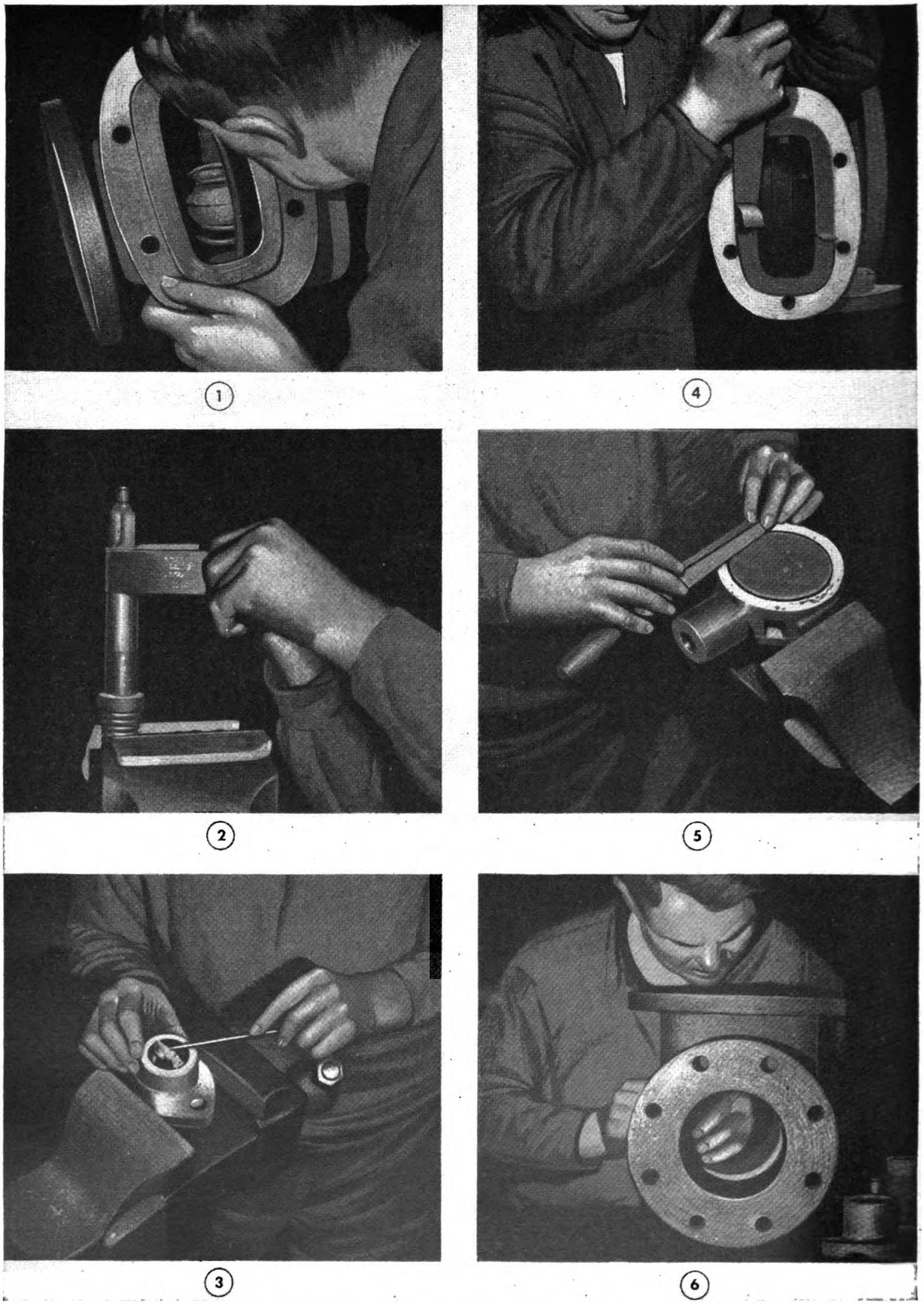


Figure 68. Steps in refacing gate valve seats.

DAILY | WEEKLY | MONTHLY | QUARTERLY | SEMIANNUALLY | ANNUALLY

101. Check Valves

17 *a.* **Inspect Disk Facing.** Open valve and observe condition of facing on swing check valves equipped with leather or rubber seats on disk. If metal seat ring is scarred, dress it with a fine file and lap with fine emery paper wrapped around a flat tool.

18 *b.* **Check Pin Wear.** Check pin wear on balanced disk check valve, since disk must be accurately positioned in the seat to prevent leakage.

102. Globe Valves

Metal disks are suitable for throttling service, plug type disks being preferable for severe throttling. Composition disks are not suitable and should be replaced as soon as leakage is noticed to avoid cutting valve seats.

19 *a.* **Lubricate Packing.** Lubricate packing and replace as shown in paragraph 41.

14 *b.* **Operate Valves and Check for Leakage.** Operate globe valves to prevent sticking. Check valve for leakage and replace disks if necessary.

* *c.* **Regrind or Renew Disk and Seat.** To prevent serious damage, repair disk and seat in globe valves when leakage occurs. Repairs on globe and angle valves can frequently be made without removing them from the line. Figure 69 illustrates the general repair procedure, using a plug type disk valve as an example; however the method applies to other globe and angle valves, except those with composition disk.

(1) Set valve firmly in vise, straight up (fig. 69(1)). Use soft jaws to prevent damage to body. Use a monkey wrench on bonnet or union ring. Do not use pipe wrench, as it will damage these parts. While parts are disassembled, inspect and clean them thoroughly. Renew packing in stuffing box, following method given for gate valves.

(2) Remove stem from bonnet. Place disk in vise and unscrew disk stem ring (fig. 69(2)).

(3) Lift out stem and insert slug or coin inside disk to take up play between disk and stem (fig. 69(3)). Replace stem and tighten disk stem ring. In some valves a pin is inserted in hole to lock disk on stem.

(4) Apply *a small amount* of emery base grinding compound to both disk and seat (fig. 69(4)). Excessive amount of compound removes too much metal.

(5) Place bonnet and body together, giving bonnet or bonnet ring two or three turns by hand to provide a guide for stem (fig. 69(5)). Keeping a firm hold, oscillate handwheel steadily until all pitting is removed and a continuous, smooth bearing on seating surfaces is obtained. Do not grind more than necessary.

(6) When grinding is completed, wipe disk, seat, and body clean of all compound and dirt (fig. 69(6)). Before reassembling valve, remove slug from disk to give it free swivel action on stem.

(7) When seat rings must be removed, use the specially designed tool (fig. 69(7)) to prevent damage to valve body.

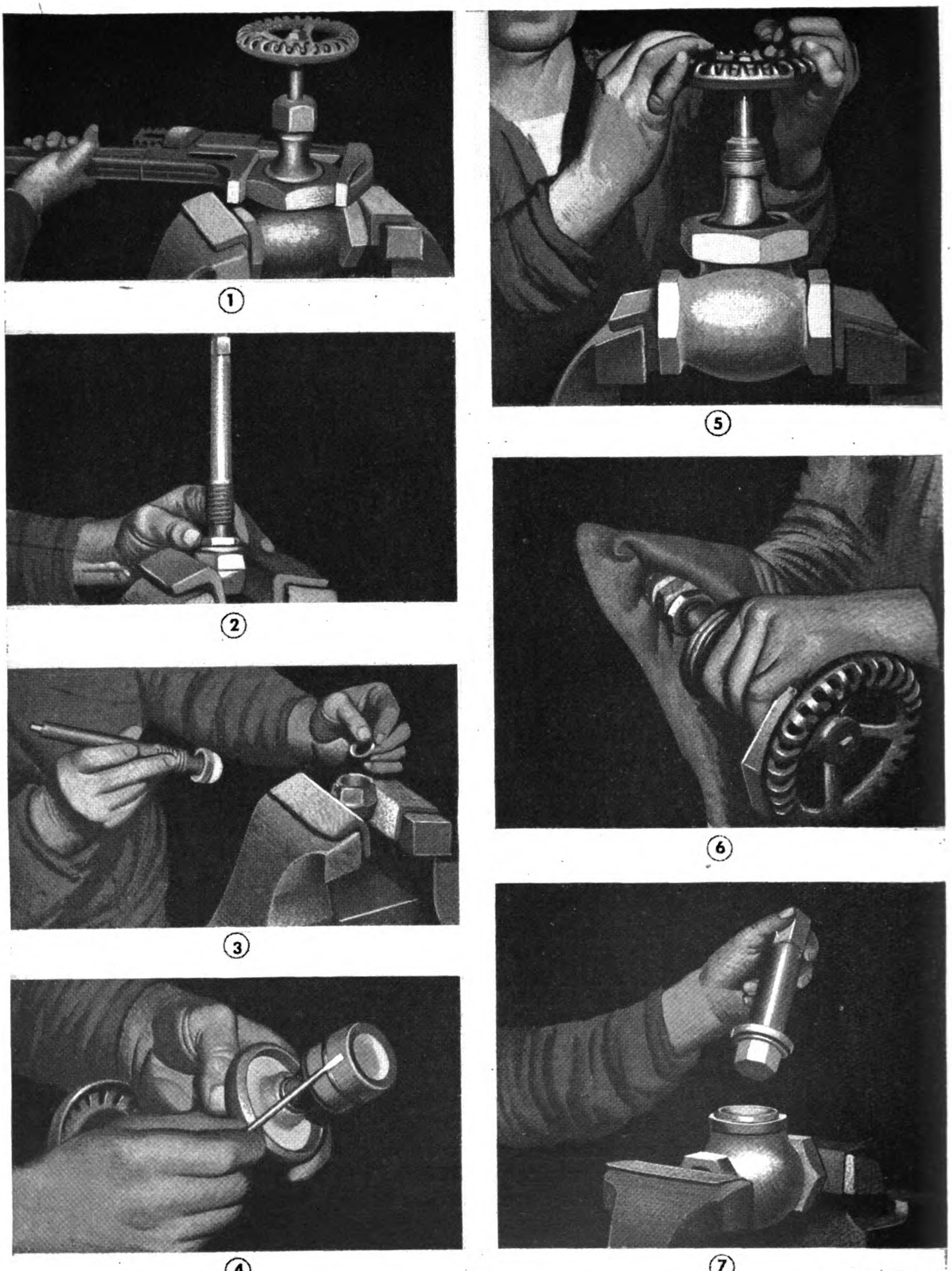


Figure 69. Steps in repairing globe valves.

103. Sluice Gates

There are two general types of sluice gates: those which seat with the pressure and those which seat against the pressure. Both are maintained similarly.

DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMIANNUALLY	ANNUALLY	
		1				*a.* **Test for Proper Operation.** Operate inactive sluice gates. Oil or grease stem screws with WB 2.
					2	*b.* **Clean and Paint.** Drain basin. Clean sluice gate with wire brush and paint with proper corrosion-resistant paint.
					3	*c.* **Adjust for Proper Clearance.** For valves seating against pressure, check and adjust adjustable top, bottom, and side wedges until in closed position each wedge applies nearly uniform pressure against gate.

SECTION XXIV
COMMAND AND TECHNICAL INSPECTIONS

104. Command Inspections

a. GENERAL. Command inspections are a function of commanding officers, made to determine the general condition of the water works and efficiency of personnel. They may be formal or informal inspections or spot checks. Commanding officers should make these inspections often enough to familiarize themselves with the capabilities of equipment, adequacy of maintenance and operation policy, extent to which the policy is being followed, and adequacy of personnel training. Since command inspections are neither technical nor routine, they do not take the place of preventive maintenance services or technical inspections. However, they should be thorough enough to reveal major faults, neglect, and carelessness. They should enable the inspecting officer to fix responsibility for defects and to note outstanding performances deserving awards of merit.

b. PROCEDURE. (1) Command inspections of water pumping and treatment plants should cover the following:

(*a*) Cleanliness of equipment and evidence of wear, corrosion, or unusual noise or vibration during operation.

(*b*) Cleanliness and condition of masonry in pits, channels, filters, and tanks.

(*c*) Completeness, convenience of location, and orderliness of tools and laboratory equipment.

(*d*) Neatness of buildings, grounds, dams, and reservoirs.

(*e*) Completeness of operating reports and maintenance records.

(2) Command inspection of the water distribution system consists of spot checks of valves and hydrants selected at random, and should include—

(*a*) Inspecting valves for full open or closed position, ease of operation, cover grade, and location marker.

(*b*) Inspecting hydrants for proper height and location with reference to road and buildings, and for damaged operating nuts and cap threads.

(*c*) Opening hydrant fully and checking for ease of operation and for excessively turbid water as main is flushed.

105. Technical Inspections

a. PURPOSE. Technical inspections are a function of the post engineer. They are made to determine the physical condition of system and plant, effectiveness of the preventive maintenance program, and need for additional training of operating and maintenance personnel. These inspections are performed by technically qualified officer or civilian personnel.

b. SCOPE. Technical inspections are made of all major functional structures and items of equipment and minor items of equipment or portions of the distribution system selected at random. They are normally made without prior notice, except when maintenance schedules or conditions require disassembly of equipment or draining of tanks. Technical inspections include:

(1) Checking WD AGO Form 5–34 Utilities (Inspection and Service Record Card), for completion of scheduled inspections and preventive maintenance services.

(2) Determining whether all higher echelon maintenance noted on the record card as being required has been completed.

(3) Noting frequency of higher echelon maintenance or repair.

(4) Inspecting individual units, using scheduled inspection items on the card and in this manual as a guide.

(5) Where higher echelon maintenance or repair requirements have been abnormal, checking loading and operating conditions carefully, and giving consideration to possible need for revision of maintenance service and inspection schedules to fit local conditions.